FOOD ENERGY

M. BIRCHER-BENNER

THE ESSENTIAL NATURE AND ORGANISATION OF FOOD ENERGY

AND THE APPLICATION OF THE SECOND PRINCIPLE OF THERMO-DYNAMICS TO FOOD VALUE AND ITS ACTIVE FORCE

BY

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INTRODUCTION TO THE ENGLISH EDITION

In reply to an inquiry the author wrote: "The book is primarily written for the medical profession. It will, however, also be understood by teachers of natural science and school hygiene, and those interested in physico-chemistry. As far as I am capable of forming an opinion, it deals with an exceptionally vital question for the teaching of biology and nutrition, which hitherto has not been recognised, so that it fills a serious gap. This book should have success, since the lesson it enforces has a great future."

In a letter addressed to Sir Joseph Larmor (September 24, 1938) Dr. Bircher-Benner says: "It made a great impression upon me to read in your letter to *The Times* (November 6, 1937) 'The discussion was about calories, but they should be calories of the available energy of Lord Kelvin rather than of crude total thermal energy.' As far as I am aware, you are the third scientist in the world who has directed attention to this problem. I believe that I was the first. In 1900, after years of study, I came to the conclusion that, in its consideration of the problem of nutrition, physiology has omitted to make use of the second law of energetics (principle of Carnot-Clausius-Kelvin). I published it in 1904, but was laughed at by my profession.

William Ostwald alone wrote that I was right. I have said that to speak of this law as the law of entropy is only to regard its final aspect—it should be called the law of the organisation of energy. Man's food should be assessed in value according to this law, i.e. according to the organisation of energy that it contains. Many thousands of patients have been treated by me with the same diet of the highest potentiality and with astonishing success. This was long before the discovery of vitamins. Thirty-five years later Dr. Werner Kollath, Professor of Hygiene at Rostock, likewise wrote about the second principle of energetics and insisted that I was right. Latterly my profession has begun to make use of this law with regard to many problems of life and disease. You will understand accordingly that your letter in *The Times* gave me great pleasure."

In acknowledging Kollath's letter Dr. Bircher–Benner wrote : 'I have with pleasurable surprise taken cognizance of your recognition, since I had thought that this revolution would only come 50–100 years after my death.'

Owing to the author's passing on January 24, 1939, the above extracts are necessarily based upon letters written by him and not intended for publication.

CHAS. E. HECHT.

April, 1939.

PREFACE TO ORIGINAL GERMAN EDITION

From 1895 onwards observations of unexpected effects of food on the diseased convinced me that the theory of nutrition then general was inadequate. In vain I sought for an explanation. Why was it that raw vegetable diet had a reviving effect on the diseased organism ? After long laborious study of the physiology and energics of nutrition, I happened upon a striking gap in those theories : The second principle of thermodynamics had never been applied to nutrition. I became immersed in the study of this principle and was rewarded by an explanation of my observations, besides finding it extraordinarily helpful in many other questions concerning nutrition.

From 1904 up to the present I have published my theories as well as practical results. The response on all hands showed an amazing lack of understanding of the energy principle—some accused me of mysticism and spoke of metagalaxis. But the effect on patients of the " second principle diet " remained favourable, and the new era of research in nutrition which began in the second decade of this century, showed many a gratifying confirmation of my ideas.

In 1935 Kollath, an eminent research worker, emphasised the necessity of consistently applying the second principle of thermodynamics to all questions of life and health, and alluded to my preparatory work. The time has now come when interest in this principle is aroused, and this priceless gift of science gives us " the opportunity to investigate the most secret qualities of substance."

It is, however, impossible to apply the second principle to this problem of nutrition as a whole without knowledge of the essential nature of food energy.

M. BIRCHER-BENNER.

Zurich,

May, 1936.

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THE ESSENTIAL NATURE AND ORGANISATION OF FOOD ENERGY

" We have to notice two things, the energy and the organisation of the energy " (Eddington).

At the beginning of my studies it seemed to me an inestimable privilege to be permitted to be a physician, because I thought the doctor would get to know the mysteries of life. However, the more I heard, saw, and experienced of life, the more impenetrable proved its mysteries. It was as if one approached a lofty range of mist-clad mountains; the higher one ascended the steeper became the walls of rock beyond, the more inaccessible the invisible summits appeared; one learnt to be humble.

To our reason the mystery of life appeared threefold: as spirit guiding and creative; as soul feeling and perceptive; and as physical existence and occurrence. The East sought above all to fathom the nature of spirit in their religious notions, and nowadays also science endeavours to apprehend the nature of the soul. But it was reserved for the West to devote its powers of discovery to fathom the secrets of the physical world, and to construct modern science with tireless struggles in research.

Meanwhile this science has now reached the confines of the realms of the soul and spirit, and so realises that man must be apprehended as a unity of body, soul, and spirit.

Anything that concerns spirit, soul, and body, belongs to the physician's sphere of interest. No fraction of this can be understood save in connection with the whole. Down to the smallest details everything human is reciprocally permeated with body, soul, and spirit. Only in so far as we are able to discern all three aspects is understanding possible. But this faculty is limited, it easily goes astray. Wherefore Henry Bergson says: " Intellect is characterised by its natural lack of understanding for life."

Our knowledge of life is *a priori* destined to remain fragmentary. But even a fragment is valuable knowledge if unremitting endeavour makes use of it as part of a vital whole.

It is in this sense that the following pages are fragmentary, although they are significant for life, nutrition, and health: they treat of nutritional energy, its nature and organisation, and the validity of the second principle of thermodynamics or Carnot-Clausius' principle in the nutritional process.

I.—THE ESSENTIAL NATURE AND ORGANISATION OF FOOD ENERGY

ENERGY, like mass, is a fundamental phenomenon of the world so far as we know it. According to modern physics energy equals mass. This equalisation is based on the results of research work, on the construction of atoms, physics of atoms, and wave mechanics. Atoms which formerly were thought to be indivisible, in the light of the new theory prove to be a system composed of protones and electrons; the proton is the electropositive, the electron the negative charge of unity. The

scientist no longer deals with matter, but with undulatory motions of ether of inconceivable velocity. Our senses perceive solid, liquid and gaseous bodies; physics, however, tells us that there is no such thing: every thing and every mass are only enormous waves of movement.

" In many instances it has become clear that things are not what they seem to be. According to the story-teller I have now in front of me a substantial desk; but I have learned from physics that the desk is not at all the continuous substance that it is supposed to be in the story. It is a host of tiny electric charges darting hither and thither with inconceivable velocity. Instead of being solid substance, my desk is more like a swarm of gnats " (Eddington).

However, this energy which constitutes mass substance, atoms, and molecules, has one peculiarity. It is *organised*, it is *ordered*.

To begin with, organisation shows in bipolarity; the negative-charged unities (electrons) are opposed by positive unities (protons). According to Bohr's description the hydrogen atom has a proton nucleus around which an electron revolves. The atom of helium consists of four protons and four electrons; four protons and two electrons form a nucleus around which the other electrons revolve. That is the kind of organisation which can be traced through the whole known series of the 92 elements including the atom of uranium which consists of 238 protons and as many electrons, out of which only 92, however, rotate around a nucleus.

This highly organised energy represents an enormous store of energy which we are unable to tap, but which under certain conditions world processes may nevertheless release. To illustrate the immeasurable vastness

of this intra-atomic energy, Eddington relates the following story:—

" We build a great generating station of, say, 100,000 kilowatts capacity, and surround it with wharves and sidings where load after load of fuel is brought to feed the monster. My vision is that some day these fuel arrangements will no longer be needed; instead of pampering the appetite of the engine with delicacies like coal and oil, we shall induce it to work on a plain diet of subatomic energy. If that day ever arrives, the barges, the trucks, the cranes will disappear, and the year's supply of fuel for the power station will be carried in a teacup, namely 30 grams of water or 30 grams of anything else that is handy."

As we have seen, 30 grams of water store as much energy within their atoms as many railway trucks of coal. Through order and organisation energy is concentrated in the least space.

In spite of man's being unable to utilise this inner-atomic energy, life itself is fed by this energy. Let us hear what astronomers have to say. In the innermost part of the solar stars the atoms are pressed together by an immense pressure at a temperature of about 10 million centigrades. They collide with such tremendous velocity that the electrons are flung out of their union and whirl about with a velocity of 20,000 kilometres per second. Nuclei of hydrogen and remnants of various atoms move about in space besides free electrons, e.g. from the iron atom out of 26 outer electrons 22 are pulled off. At every moment swirling round electrons encounter remnants of atoms with which they unite only to be flung away in the next second. But whenever a free electron is captured by a residue of an atom, an X-ray forms which travels at a velocity of 300,000 km. a second.

Multiply these happenings billions of times and we may conceive something of the formation of radiant energy out of intra-atomic energy. The jump of a free electron into the exterior path of the atoms corresponds to the exact period of oscillation of X-ray light, the energy of which is determined by wave-length and frequency and represents the " quant " of a proton.

Two theories are available to explain the transformation into radiation of intra-atomic energy within solar stars. According to one, radiation arises from complete annihilation of matter, proton (later positron), and electron, that is to say positive and negative charged units coalesce and so neutralise one another.

" The idea is that when a proton and electron run together and neutralise each other, nothing is left but a splash in the ether representing the energy of constitution which is now set free. The splash spreads out as an electro-magnetic wave, which is scattered and absorbed until it is converted into the ordinary heat of a star " (Eddington).

According to the second, more probable explanation, light energy is liberated by formation of an atom of helium out of four atoms of hydrogen. Eddington's words are:—

" The material for a helium atom is thus precisely the material of four hydrogen atoms. But although the material is the same the mass is not quite the same ; the helium is lighter by about 1 part in 40. By Einstein's law of the equivalence of mass and energy, the mass-defect is a measure of the energy that must be liberated when hydrogen is transmuted into helium."

According to the first theory, the energy storage of the sun would last for 15 billion years, whereas the radiating

energy gained by forming helium would be used up in about 150 million years.

The electro-magnetic, radiating energy formed under the above conditions in the nucleus of the sun, permeates the entire solar mass, its wave-length increasing and its frequency diminishing until it quits the solar surface as light at a temperature of about 6,000 degrees centigrade and shines into the universe and upon the earth. So we see that the solar energy which is essential to life is formed within the sun at a temperature of 10 million degrees centigrade and leaves the sun at 6,000 degrees. At the same time we have become acquainted with two kinds of energy, intra-atomic and radiant, energy which travels in the ether at a velocity of 300,000 km. per second. Besides X-rays and light rays, cosmic rays belong to the later group, the frequency of which is still greater than that of X-rays, and the Hertzian waves with a lower frequency than infra-red light rays.

Light, too, is radiated in units or quants or protons, i.e. in exactly measured wave periods, the energy of which decreases in frequency and wave-length, going from ultra-violet to infra-red.

After having realised the formation of light out of matter as the first relation between both, we must consider the second relation, namely absorption and emission, viz. retention and radiation of light through matter.

All that has to be said about this second relation of light with matter would be far better left to a physicist. I am afraid my description will be very inadequate. The reader must bear in mind that I am only a physician endeavouring to point out what I have understood. To get a clear conception of those relations I relied upon

spectroscopy, Bohr's teaching on the structure of atoms and the theory of quants.

Spectral analysis proves that each atom in the series of elements emits a smaller or bigger chord of light according as it becomes radiant by heat. This radiant accord appears in the spectrum as a series of shining lines, each in the place on the wave scales characteristic of that element. Between the lines of the series of an element, harmonious relations exist, not unlike the relation of notes in a chord of music. They can be mathematically defined by Balmer's formula. If we adhere to the comparison with waves of sounds we imagine there to be within the atom a number of tuning-forks of definitely determined wave-lengths, corresponding to the number of lines in such a series; they start sounding when heated and send forth their corresponding waves of sounds, in our case waves of light. Spectral analysis identifies each of the 92 elements by its specifically characteristic chord ; its linear spectrum.

That is the way of emission of atomic light. But what is absorption like; the absorption of light by the atom ?

The atom absorbs, i.e. receives the same wave-lengths of light which under other conditions it would emit. If a certain sound is sent forth through the air in the presence of a number of tuning-forks, only that tuning-fork will resound which gives the same note when struck. Let us imagine every atom of the 92 elements to have its own " tuning-fork register," then every atom will be able to absorb that wave of light of the rainbow colours of the totality of light which corresponds to its note.

Indeed, this register of tuning forks is really present among atoms, as Bohr's theory of atomic structure proves.

Electrons rotate around the nucleus in each atom, 1 electron in the atom of hydrogen, two in helium, and so the number of rotating electrons of the series of elements increases by one up to uranium, with its 92 electrons.

It can be proved that the paths of these revolving electrons around the atomic nucleus obey certain laws. These paths are arranged concentrically, their distance from the nucleus increasing gradually until it is merged in infinite space. The circuit next to the nucleus is at the same time the lowest level of electronic energy. Only two electrons can be admitted. The next circuit contains two levels of energy and two pairs of electrons can be admitted in each, so that the maximum of eight electrons can be reached in the second circuit. The third has three levels of energy, each of which can admit three pairs of electrons, so that the maximum number of electrons in the third round is 18. The fourth round has four levels, each of which can contain four pairs of electrons, the total number being 32. The electrons of the outermost circuit of an electron are called valence electrons, as they are determinative with regard to chemical relationship.

In the seventh round the number of energy levels around the nucleus has reached 28. If an electron of the outermost is driven away into infinity, it no longer belongs to the atomic union. If the inner rounds are entirely full up and the valence atoms occupy the next circle, the atoms will be in a state of relative low energy. The same holds good for molecules. The situation of individual paths of atoms and molecules is such that under no circumstances can any alteration set energy free. The system is in a condition of utmost stability.

An alteration of this stable condition can only be provoked by the introduction of new energy. That happens through absorption of light. When the valence electron is offered a light quant of corresponding frequency by absorbing the quant, it " jumps " out of its path into a higher round, that is into a higher level of energy. The system augments in energy, exactly corresponding to the quant which has been absorbed. It is in a state of " stimulation " ready to emit energy. Corresponding to our simile the same relationship exists between the absorbed light quant and the alteration of energy level of the electron, as between the waves of sounds and the tuning-fork. Increased frequency of the wave-periods of a quant augments the size of the electron's " jumps." An X-ray quant is able to fling an electron out of the atomic union.

In a substance which absorbs light those jumps of electrons take place billions of times in its atoms and molecules. The whole mass of valence electrons may be thrown into higher levels of energy. The increase in energy as an outcome of absorption, the state of " stimulation " is measured by quants of light. Quant after quant can continually be disposed of. The delivery of energy occurs at the instant that an electron jumps back from a path further away from the nucleus to one which is nearer to it.

" In a process which consists merely in a fall of an electron from a level to a more stable one energy is emitted as monochromatic radiation; the frequency of this radiation multiplied with Planck's constant h is equal to the difference of energy between both states of the system " (Lewis).

Emission is the most direct way of liberating absorbed

light, as linear spectrum in the atom, as ribbon-spectrum in the molecule. In this case there is a luminescence of matter. Wherever there is luminescence there is setting free of light quants, through falling electrons. There are as many differences in the values of energy of light quants as there are differences in frequency. The higher the frequency, the higher the energetic value, that is the potential.

Augmentation of energy of a system (atom or molecule) through absorption of light may be utilised in different manners. The biologist and the physician are principally concerned with its use in the processes of reduction and of building up complicated organic molecules.

In the chlorophyllaceous leaves of the plant, water and carbonic acid are reduced under absorption of light, and oxygen is split off. In this process of oxidation where hydrogen and carbon become water and carbonic acid by taking oxygen, a large amount of warmth is liberated. The same amount of energy is necessary to reduce the chemical combination. It might be attained by very high temperatures. In leaves, however, the reduction is carried out at the ordinary temperature of the earth. This process is puzzling and needs explanation.

High temperatures are the measure of strength or intensity or potentials of heat energy. Equivalent to them are strength intensities or potentials of light quants. At 10 million degrees centigrade the solar nucleus forms X-ray quants; at 6,000 degrees centigrade the solar surface forms solar quants, each with their corresponding potentials. The latter have therefore the same productive power as high temperatures. When the physiologist Pflüger foresaw that within the living cells a temperature of 2,000 degrees centigrade must exist, there was as yet

no physics of atoms and no theory of absorption of quants.

Nowadays, however, we are compelled to admit that the electrons of the molecules H^2O and CO^2 take up as many quants of light as are needed in the process of reduction. Logically we conclude that the newly established phase of reduction represents a well-defined value of light quants, and in that case energy being used by vital processes, those light quants are set free.

The difference between oxidation as seen in combustion and that of the vital processes must therefore be as follows: In the first case the light quants have been absorbed to enable chemical reduction of energy to be changed into warmth ; in the second instance, however, they are chiefly liberated as light quants or electro-magnetic energy respectively and utilised for the process of the cell-life. That explains how the vital processes of oxidation take place without any rise of temperature.

I may be accused of seeming to imagine the light process in green leaves to be so simple that CO^2 and H^2O are split in C, O_2, H^2 and O and C and H are used for building up carbohydrates. I am well aware of the complicated intermediate processes, but what I want to make clear is that for my contention they are of no importance, as in the end the number of the necessary light quants remains unaltered and their total sum remains the same.

We are concerned with the specific character of nutritional energy and the question of energy exchange in the synthetic building-up of such manifold, various, and highly complicated molecules as constitute living substance, especially that of proteins, carbohydrates, and

fats. The question is, however, so complicated as far to surpass my slight knowledge of chemistry.

It would be worth the while of some great physico-chemist to study. Those molecules show the most remarkable combinations of C–H and O in various amounts and of carbohydrates and nitrogen combinations and minerals reaching molecular weight of 98,000. The little I could grasp was that in forming such molecules, energies again intrude the molecular union, and that this process, taking place under photo-chemical conditions, is performed by absorption of light quants by the molecule which comes into existence.

These conceptions of molecular energy—in other words, the dynamic correlate of molecular structure—holds good also for lifeless molecules. Ingo W. D. Hackh, the physicist of San Francisco, has formulated a plausible theory explaining the nature of the quants in the living substance of cellular protoplasm. According to this, the molecule of the living compared to the inanimate protoplasm has an additional charge of light which raises the total amount of valence electrons of a molecule to a higher energy level (circuits more remote from the nucleus) and thus produces the " stimulated " condition of the molecule. In this condition, says Hackh, intra-molecular shifting of the charging of quants provokes pulsation of the molecule; it starts emission of light, i.e. luminescences. That is why the living cell, the plant cell as well as the animal, emits light as first shown by Gurwitsch and later, too, by Glasser, Cleveland Hospital, who undertook to measure the wave-length emitted.

The death of the cell ends luminescence or light emission respectively; electric potentials of the cell

simultaneously drop to zero, which Telkes in amœbæ found to measure 15 millivolt.

These deductions, based on the physics of atoms, theory of quants, and spectroscopy form photochemical processes in the growth of the living plant, lead to the following conclusions:—

(1) Formation of living matter in Nature viewed energetically is closely connected with an appropriate organisation of the absorbed quants of sunlight directed by some spiritual source of life.

(2) The relation between atoms and molecules on one side and frequency of light rays on the other, as established in spectroscopy, are to be found in this absorption and organisation. Therewith we might be able to understand the purpose of the selection and distribution of the elements used by life in the fully developed organs of the plant. Absorption and organisation of light energy are adapted in a specific way in every plant, even in every organ of the plant. The question arises in how far this specification depends on the particularities of the system established, as well as on the distribution of elements, e.g. minerals in the organs of the plant. This question concerns the problem of biological effects of nutrition, the effect being a result of organisation of energy.

(3) Absorption and organisation of sunlight, the essence of life, take place almost exclusively within the plants. The organs of the plant are therefore a kind of biological accumulator of light. They are the basis of what we call food, whence animal and human bodies derive their substance and energy. *Nutritional energy may thus be termed organised sunlight energy.* Hence sunlight is the driving force of the cells of our body.

These simple logical conclusions are not in agreement with the short-sighted notion of calories being the nourishing energy. But the new truth will gain ground. *La verite est en marche !* An organisation of light quants is wholly different from a calorie, although a calorie may be derived from it. A Beethoven symphony taken altogether constitutes a certain sum of vibrations of the air. But the same sum of vibrations will never be a symphony. A calorie is a certain sum of molecular movements. This, however, does not tell me anything about its origin, which might have been dynamite, gun-powder, wood, gas, coal, electric current, or an ingenious organisation of light quants. A calorie is like a disorderly noise in the world of molecules: a green leaf, an apple, a strawberry, a cherry—each of these is like a symphonic poem where sound and thought form an artistic unity.

This theory of sunlight values of food is supported by natural science and by experiments. The following is a report by the research worker, George W. Crile, Cleveland Clinic:—

" A striking example of physical property in living organisms is the Gurwitsch radiation discovered by the Russian investigator of that name. Gurwitsch was not able to demonstrate this radiation directly, but he demonstrated it indirectly by the effect on cell division and growth when the tip of one onion root was placed against the side of another onion root. The presence of one growing tip had the effect of increasing rate of cell division in the other onion root.

" Dr. Glasser was the first to demonstrate these radiations directly by physical methods, first, by securing photographs of the radiations, and later by recording

them by means of a photo-electric cell and Geiger-counter on a tape recorder and a loud speaker; Dr. Glasser has recorded such radiations from a frog's heart, from yeast, from cancer and from the autosynthetic cells which will be described later.

"The Gurwitsch rays are analogous to the rays producing the visible spectrum which are exhibited by many animals, notably the firefly; they are analogous to the infra-red radiation generated and emitted by virtually all animals and plants. That is to say, animals and plants generate and emit the components of the solar spectrum. It would indeed be strange were this not the case, as, so far as is known, the energy of life on the earth is derived directly or indirectly from the sun's radiance.

"The carbon atom in the plant cell receives and stores within itself the sun's radiance in the process of synthesising carbohydrates. Now it is a physical fact that when an atom that receives energy of a certain wave-length emits the energy received, the emitted energy will have the same wave-length or a longer wave-length, never a shorter wave-length, than that which was received. Therefore when carbohydrates are burned or oxidised, there must be emitted radiance out into the carbon atoms by the sun when carbohydrate was formed. . . . The same law holds for living organisms, that is the stored radiance of the sun must be set free from its capacity in the atoms. The radiations thus emitted supply the energy which organizes and drives living organisms.

"As has been stated, the protoplasm of animals emits radiations of various wave-lengths, some short, hence as powerful, as those emitted by the sun. It

follows that an animal emits radiation that can change the electrons of atoms in the same manner that the sun's radiance changes the electrons of atoms. In other words, the sun " shines " in the protoplasm of animals and plants, and, therefore, animals and plants can confer on atoms chemical affinities such as are conferred by the sun. But to produce ultra-violet radiation of the wave-length of ultra-violet light, a temperature of from 3,000 to 6,000 degrees centigrade is required. This, applied to a human being, would seem preposterous. Who would think that there are ' hot points ' in man and animals of the order of the temperature of the surface of the sun ? But if Gurwitsch, Dr. Glasser, and others are right in their experimental evidence that ultra-violet radiation is generated in protoplasm, these facts must be harmonized."

It is extremely fascinating to read of Crile's ideas on the problem of the temperature of energy in living matter ; the problem of temperature being synonymous with the problem of potentials of nutritional energy. He continues :—

" Rutherford states that the chance of hitting a bird when shooting at random is as great as that of hitting an electron when an alpha particle passes through an atom. The chance of an X-ray collision with the proton or electron in an atom is as improbable as would be the chance of hitting a planet or the sun by throwing a snowball through the solar system. It is the inconceivably small size of the protons, the electrons, the atoms and the molecules that makes it impossible for our minds to appreciate it—and at best the idea can only be crudely represented by parables and analogies. Only the conception that the hot points are infinitely small and the

interspaces infinitely large in comparison, can make acceptable the conception of a temperature as high as that of the sun itself in relatively cool protoplasm. The relatively free spaces between the atoms and molecules in protoplasms are vast, and it is because our minds are not accustomed to think in terms of the infinite that it is difficult to grasp the fact.

" Although the sun has an outer temperature of from 5,000 to 6,000 degrees centigrade, a temperature which we conceive to be that of the infinitely small points which we may call the ' suns ' or ' radiogens ' in protoplasms, neither the solar system as a whole, nor the protoplasms, has a high temperature. The solar system and protoplasm alike have only moderate temperatures, because of the vast relative spaces in the solar system and in protoplasm wherein is absorbed the radiation emitted from the points of high temperature. In other words, it would appear that the sun's radiance has set up infinitesimal ' suns ' in protoplasm which generate and emit radiation identical with the sun's direct radiance in the plant cells. That is to say, the sun shines with undiminished radiance in the protoplasm of animals. If one could look into protoplasm with an eye capable of infinite magnification, one might expect to see radiogens spaced like stars as suns in infinite miniature. We may say that protoplasm is a milky way consisting of ' solar ' systems infinitely diminutive, each created in its own image by the sun's radiance. The nucleus or ' sun ' of our theoretic radiogen would theoretically be a molecule of iron. Dr. Telkes has calculated, on the basis of the amount of iron present in muscle, that in a cubic centimetre of muscle there would be on the order of four billion radiogens or protoplasmatic ' suns.' Those

radiogens we may suppose to be exclusive mechanisms of energy transformation—exclusive centres of protoplasmic activity and growth."

Here is an attempt full of imagination but based on natural science which endeavours to solve the problem of chemical potentials of protoplasm. It is a counterpart to Pflüger's conception of the cell as a minute laboratory with temperatures as high as 2,000 degrees centigrade.

Curiously enough, Crile's conception assumes temperatures as high as those of the solar surface in protoplasm or its radiogens respectively. It shows how the logic of facts compels the scientist to form a notion of the potentials of the chemical energy of nutrition and that they compare this potential with solar temperatures. The theory of quants gives a different solution, but with the same results in respect of the heights of the potential, as shown by the foregoing.

The potential designates intensity or strength of energy. When energy appears as heat its potential is measured by temperatures. Warmth is " unorganised movement " of molecules. Temperature is, so to speak, a measure of frequency of molecular movement. The greater the velocity, the higher is the temperature. In electricity voltage is the measure of potential. In a waterfall the potential corresponds to the altitude of the fall, in moving masses to velocity, i.e. to the momentum. Chemical energy always ensues from a " closed system," its potential therefore cannot be measured in a direct manner as with temperature or voltage. Nevertheless potentials of plants which result from transformed chemical energy are known as they are exactly equivalent to the potentials of absorbed light quants. The energy of a light quant, however, is $= h \times v$. h is the constant of Planck and possesses

0,000,000,000,000,000,000,000,000 665 erg-seconds. v is the frequency of the monochromatic radiation of the light quant and this frequency is its potential—alias its temperature.

The light which has been absorbed by the electrons of a system (atom or molecules) has now become chemical energy that is free energy as long as it remains within the system. Under certain conditions this energy will be emitted by the system. Emission takes place in the same way as absorption, by quants, each quant according to its specific potential. The potential can never rise. If the emitted light quant has a smaller frequency, that is to say longer wave-lengths, the potential has dropped. In that case a fraction of energy has been consumed in the system. Potentials in a system are not able to increase in strength, either they remain constant or fall. They fall, e.g. if part of the energy is spent in warming the system. It is doubtful whether warmth is produced by the consumption of nutritional energy, e.g. whether the light organ of a glow-worm gets heated by emission. The warmth production of a cell performing vital work is not derived from warmth formation in the chemical system, otherwise, as Crile observes, the cell could not emit rays as powerful as the sun.[1]

Hence the probability exists that light quants absorbed by the plant are transferred in undiminished potential strength to the cells of the more complex system, when the plant enters an animal or human organism as food.

[1] To the audience at this lecture Crile demonstrated light emission of fresh brain substance in a *completely* darkened room. According to Dr. Telkes, one of his collaborators, the type of radiation emitted by the brain tissue in the previous day's demonstration includes, in addition to visible light, infra-red radiations of a range from 8,000 to 12,000 angstrom units. The tissues likewise give off shorter radiations in the range of ultra-violet.

According to Stephan's law of temperature radiation intensity of light corresponds to the temperature of the source of radiation; the intensity of sunlight and the potential sum of its quants corresponds therefore to a temperature of about 6,000 degrees centigrade. The effects are determined by the strength of the potential. We are thus able to follow Pflüger's assertion that processes take place in the miniature laboratories of the living cell which otherwise only occur at temperatures of several thousand degrees. Crile's logic also becomes clear with its 6,000 degrees points of heat or protoplasm suns of radiogen. Such were the speculations arising out of the search for the concept of the potential.

These scientific observations lead us to a radically new insight into the nature of the energy of food. And as both man and animal take food chiefly for the sake of energy, fresh light was shed too upon nutritional value. Edible vegetable organs are the *original food* of man and animals, from which every dish including animal products is ultimately derived. This original food conveys the energy of sunlight as organised by life. It conveys light quants to the organism being fed " with equally powerful potentials as those of sunlight." So we understand Crile when he says " that the energy of animals (including man, the author) is supplied by re-radiation of solar energy in their plant food."

In medicine it is customary to regard the supply of vital energy chiefly from the standpoint of the supply or consumption of calories. The power of custom is so great that hardly anyone realises that the caloric value of foodstuff does not give the slightest indication as to the character of its energy or its potentials, much less about any organisation thereof.

An electric apparatus, e.g. a diathermic, can only be set going with electricity, and besides, each apparatus requires its definite kind of current and certain voltage. A lamp constructed for alternating current of 220 volts must be fed by that particular current. If an alternating current of 300 volts is sent, it will burn up immediately. Or if an alternating current of 110 volts be supplied the light emitted will be reduced by a half. Hydraulic works built for a fall of 100 metres cannot be worked at 10 metres water power. The turbines must be built according to the specific fall, and the amount of water has to be varied to obtain the desired kilowatts. Eddington's imaginary power station that is built for coal energy and is capable of supplying 100,000 kw. could be driven by the intra-atomic energy of 30 grams of water only if all the machinery were entirely changed. Theoretically the yearly output of the 100,000 kw. works could be produced either by many train loads of coal or by 30 grams of water, but what an immeasurable difference in the machinery required !

But however much these things may change, the 100,000 kw. remain 100,000 kw. and do not reveal the kind of energy or the astonishingly different machinery by which they were produced. It would be wholly impossible to exchange the energies or machineries or to drive one or other partly with water-power of the same kilowatt. The one machinery must have many trainloads of coal, the other 30 grams of water; only this kind of food suits the machines and the 100,000 kw.

Exactly comparable are the 3,000 calories required daily by a man weighing 70 kilos and doing moderate work. They don't tell us anything about the nature of the energy which drives his " power station," nor about

the machinery of cells and organs with which this energy must work. It is, however, certain that his " machinery " cannot be kept going with either coal or the intra-atomic energy of water, neither by electricity of any voltage whatsoever, nor yet by hydraulic power of a waterfall. He must be fed on food (more or less) suitable to man. His food is itself a product of life. Man derives his food from the animal and vegetable kingdoms and he utilises his food in many ways without asking what happens to its energy content.

Let us now consider the phrase—human food is a product of life. If we regard it as energy it cannot be compared with various energies of the inanimate world. Hence after establishing that its energy is built up of light quants, we are forced to describe food as an *organisation of the energy of light.*

I would like to endeavour to say a word about this biological organisation. It will be brief and quite inadequate, since so far as I know this problem has not yet been investigated.

How is life organised ? Obviously in perfect accordance with the structure of atoms and their physics, the laws of energy, mass and matter, the theory of quants, the absorption and emission of light, etc., and with a supreme mastery of the use and applicability of such things.

Martin Sihle, a physician of Riga, has dealt with this question profoundly and convincingly in his two books, " Ueber das Weltbild des Arztes und den Sinn der Krankheit " and " Das Urphänomen des Lebens." In brief, the prime phenomenon of life and of all living things is the coupling of spirit and matter (or energy) in such wise that antagonistic tensions which exist in the

inanimate world as ordered series of waves of ether (atoms, molecules, rays, etc.), are brought into organised partnership in order that their united energies may perform purposeful and productive work. Hence among the fundamental phenomenon of the world there appear: partnership of antagonists, directed aim and work, the basis of which lies in the attack of a spiritual principle directing the creation of new ordinances.

" As every phenomenon in life must be based upon dynamics, viz. energy or tensions, we however perceive life as a continual succession of tensions, released antagonistically and synergetically (in partnership). Thus we reach the conclusion of the formulation of our axiomatic thesis: Vital processes, i.e. physiological-biological processes are antagonistic and synergetic (partnership) tensions, which while continually varying only result in the productive work of functional activity by the uninterrupted coupling of these tension complexes-factors of direction pre-existing " (Sihle, " Das Urphänomen des Lebens ").

The reader may find this quotation scrappy and unilluminating, but I assure him the book is well worth reading if language and circumstances permit.

The source of organisation is therefore discovered ! It is the spiritual principle which after mastering and ordering the waves of the ether attacked the world anew and, by coupling, created a new realm of ordinances purposefully directed towards productive functioning.

Food energy must satisfy the needs of the organism to be fed; this is the directive purpose bestowed on organisation by the spiritual principle of growth. Food and organisation—two organised phenomena which should be in harmonious relation to each other. In

animals and man the demands of this harmony in the region of forms extend to the structure of the organs of consumption and digestion.

Food should supply everything needed by the organism's energic activities:—

(1) The various energic frameworks storing light quants which appear as stages of reduction and possess definite potentials are called *redox-potentials* because they are raised by reduction and are consumed by oxidation. Among these are all proteins, carbohydrates, and fats, in " stimulated state " and in the correlative quantitative condition existing in them as constituents of the total nutriment.

In his exegesis Crile points out that all proteins, carbohydrates, and fats, being relatively stable combinations, their energy could not be made use of in the life of the cell without " ignition." Proteins act as kindling matter, their molecules containing carbohydrates and nitrogenous compounds. Through introduction of nitrogen the molecule changes into an explosive substance. Metaphorically speaking, proteins and carbohydrates in energic consumption may be compared to priming matter and powder in a cartridge. Whence results one of the correlations of the quantitative proportions between proteins and carbohydrates and fats respectively, at which the organisation of food energy must aim because it is of importance for the cell's energic activity.

(2) The regulators of energy consumption which either inhibit or sustain acceleration such as catalyzators, vitamins, etc. Amongst them are some which facilitate so-called " coupled reactions," that is when new redox-potentials are introduced into an oxidised system which

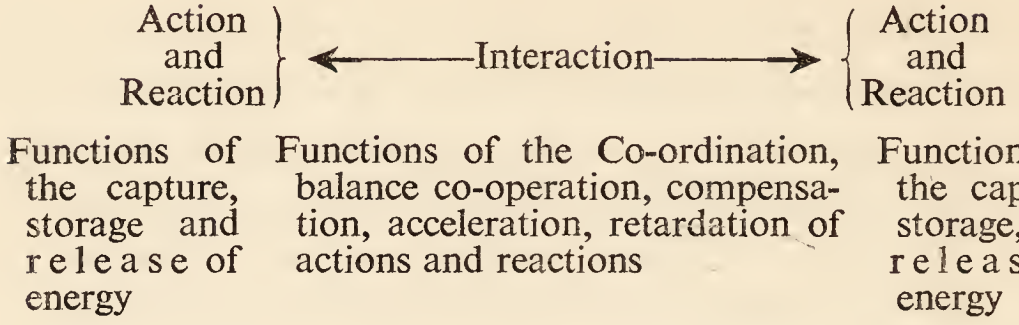
enables reduction to take place and thereby obtains new productive faculty (most of the vitamins, glutathion).

(3) The apparatus, or little machines (metaphorically speaking) with which cell energy is supposed to perform its specific work. Apparently very little is known of these vital constructions and their use as building material of the body. In every case proteins and organic compounds of mineral substances belong to them. These systems are also organised forms of energy which are based in accordance with the fundamental phenomenon of life and modified in the chromatin of the species. It may be assumed that those constructions are partly introduced with food in preliminary forms which are easily transformed, and are adapted in the organism to to suit its specific working plan.

With this we may compare the following passage from H. F. Osborn's " Origin and Development of Life ":—

" Out of these physicochemical principles has arisen the conception of a living organism composed of an incessant series of actions and reactions, operating under the dynamical laws which govern the transfer and transformation of energy.

" The central theory which is developed in our speculation on the Origin of Life is that every physicochemical action and reaction concerned in the transformation, conservation, dissipation of energy, *produces also either as a direct result or as a by-product, a physicochemical agent of interaction which permeates and affects the organism as a whole or affects only some special part.* Through such interaction the organism is made a unit and acts as one, because the activities of all its parts are correlated. This idea may be expressed in the following simplified scheme of the function or physiology of the organism.



" Since it is known that many actions and reactions of the organism—such as those of generalised and localised growth, of nutrition, of respiration—are co-ordinated with other actions and reactions through interaction, it is but a step to extend the principle and suppose that all actions and reactions are similarly co-ordinated; and that while there was an evolution of action and reaction, there was also a corresponding evolution of interaction, for without this the organism would not evolve harmoniously."

" Evidence for such universality of the interaction principle has been accumulating rapidly of late, especially in experimental medicine and experimental physiology. . . . It is the peculiar evolution and elaboration of the physical principle of interaction which distinguishes the living organism.

" All visible tissues, organs and structures are seen to be the more or less simple and elaborate agents of the different modes of energy. One after another special groups of tissues and organs are created and co-ordinated —organs for the *capture* of energy from the inorganic environment and from the life environment, organs for the *storage* of energy, organs for the *transformation* of energy from the potential state into the states of motion and heat. Other agents of control are evolved to bring about a harmonious balance between the various organs and tissues, in which energy is released, hastened or

accelerated, slowed down or retarded, or actually arrested or inhibited."

It becomes obvious on consideration that in plants not only the organic, better biological carriers of energy of the various " thoroughly constructed " organisations, are mainly " ready made " for use in the animal and human organism, but also the agents and systems of intermediate effects or at least their preliminary forms. At the same time, co-ordination of the systems is provided for, i.e. for the proper correlations making for harmonious balance in the coming interplay of actions and reactions to take place in the nourished organism.

This highly developed organisation of nutritional energy, constituting a well-balanced co-ordination, might be called the biological-correlative organisation of nutritional energy.

All that, and much more of which I am ignorant, has to be performed by vital forces through organisation of sunlight energy within the plant until what is called human nutriment ensues. Therefore, I postulate, nutrition in its natural state such as fruit, green leaves, grain, roots, etc., is like a symphonic poem blending sounds and thoughts together. The poet or composer is evidently a genius of superhuman dimensions. However, even the greatest symphony gives but a faint conception of the grandeur of art and wisdom operative in those productions. A verse by Joyce Kilmer comes to my mind:—

" Poems are made by fools like me
But only God can make a tree."

Every single organised system, whether it be called protein, carbohydrate, fat, mineral, or any other substance, is a premeditated, well-calculated work of art.

The harmonious combination of the whole, the subtle correlation of all the systems or nutritional factors, the planned equilibrium of the single factors inherent in this work of creation called nutriment, seems to me amazingly vast.

With what *naïvete* indeed has the medical profession hitherto treated the natural nutrition-products ! It was actually believed that man could exist on fats, carbohydrates, and proteins, and ultimately on calories. We applied this primitive standard to measure the nutritional values of food and its efficacy. Decades ago we had already been warned by von Bunge. He made artificial milk of fat, protein, carbohydrates, and mineral salts, in correct proportions, and tried to feed mice on it. They all died of starvation, just as though they had been deprived of food. But this warning was disregarded. Again and again we tried to treat patients with a diet based on these standards. The amount of calories in diet was prescribed and protein increased. It was a hopeless failure.

The discovery of the main constituents of nutrition by chemistry certainly signified progress, and the calculation of calories was an achievement of considerable importance. But the problem of nutrition remained far from being solved by these discoveries. The results of the new era of nutritional research have abundantly proved how inadequate our former knowledge was. However, the majority of people are somewhat conservative, including the " learned men." " Ours is the age of the mass mind," says Ortega y Gasset, and man in the mass is distinguished by his unteachableness. He is content with what he has learned for his examinations and has no desire for further exertions.

However, the welfare of the healthy and the diseased imperatively demands a change, to which I hope to contribute my share by this treatise.

Summary.—Nutritional energy is ordered and organised by the creative life principle. It thus differs from all other forms of energy. Its producer is sunlight, the absorption of which takes place mainly in plants. There, light quants are turned into electronic energy in the synthesis of organic molecules. These molecules are systems that receive energy in the form of light quants and are capable of emitting it again as light quants. This kind of emission of free energy is most likely to occur in the working of the nourished organism. As their synthesis is the result of processes of reduction, reduction-oxidation potentials ensue called for short " redox-potentials," the significance of which will be described later. Altogether the potential strength of energy in natural food is equivalent to sunlight energy, i.e. to a temperature of 5,000 to 6,000 centigrades.

Besides the formation of these carriers of energy systems, there are agents and systems for intermediate effects of future vital processes for which energy is supplied by food, such as catalyzators, enzymes, vitamins, redox-potentials, which are supposed to inhibit or accelerate the consumption of energy. Partly they are only preliminary grades.

Lastly, instruments or " working machines " for the cells are produced, most of them probably as preliminary grades which are added to nutriment in the form of proteins and compounds of mineral substances. These " machines " are adjusted to the specific organised energy and its potential strength.

The highest degree of organisation is attained when all

these various energy factors are purposefully co-ordinated in definite proportions, with determined natural correlations making possible harmonious equilibrium of their effects distributed throughout the nutritional unit.

The totality of the organisation may be called *biological-correlative organisation of nutritional energy*.

Thus man is not nourished merely by calories, but by an ingenious organisation of systems of light quants.

A REMARK ON CORRELATIONS

We do not yet know the natural correlations of the totality of nutritive factors which are adequate to the human organism.

Voit's standard formula was acquired empirically and referred only to three main nutritive substances; in the course of time it proved untenable and misleading. The adult is supposed to take 16 per cent. of his calories as protein, whereas Rubner stated that mother's milk provides the quickly growing infant with 7·3 per cent. only, which leads to the conclusion that the actual needs of adults must be below 7·3 per cent. Voit's standard means a surplus consumption of protein by 200 to 300 per cent.

Rubner already made it clear that over-consumption of protein by no means strengthens the body, but through the specific-dynamic effect of protein and secondary nutritional influences leads to injury of metabolism.

Katase and his collaborators, in their thorough research work, proved that excessive consumption of the main nutritive substances produces acidotic conditions of constitution such as dental caries, paradontosis, alimentary osteopathy, drop heart, infantile womb, myasthenia, asthenic types, etc., and increases the dis-

position to juvenile diseases. Therefore Katase emphasises the necessity of a harmonious combination of nutritive substances in our food.

Chittenden (1905) and subsequently his former opponent Benedikt (1918), in their extensive nutritional experiments with " economic " protein administration, observed the disappearance of ailments, improved general health, and increased energy, results which we are able to understand better now than we did then.

Many outstanding facts were brought to light by the new era of nutritional research. They show correlations, important for health, between vitamins among themselves, between vitamins and mineral substances, between mineral substances among themselves, between mineral substances and vitamins, vitamins and nutritive substances; their significance being fully appreciated, especially in the brilliant papers of Werner Kollath.

There can no longer be any doubt that the human organism needs nutritional substances in adequate correlations, that there is an optimum of correlations, and that dyscorrelations may injure health and constitution.

Breast-milk of a mother living on a correct diet may be assumed to contain correlations adequate to the infant's needs. Wrong diet will make the milk dyscorrelative. Von Bunge taught us the composition of mother's milk is adapted to the rapid growth of the child. It is born with a certain iron reserve, whereas the milk hardly contains any. We do not know whether there are still other similar particularities besides this in the composition of breast-milk. However, it is evident that the correlations of breast-milk can in no wise be regarded as a valid standard for the elder child or adult.

The correlations of vegetable nutriment—provided it is grown under sound conditions—are determined by the structure and working plan of each particular plant. Every plant organ has its specific correlations according to the needs of the embryo in the different fruits. Structure and working plan of the organism are part of its soul, and so are its correlations. Therefore I venture to say: By eating an apple we make contact with the soul of the apple-tree.

The same would apply to animal nutriment, if it consisted only of the animal embryo, or if like wild beasts we first drank the blood, then ate the entrails, bones, fat, and meat last. In reality man eats only special organs, more correctly tissues—above all—flesh. Flesh, however, has extremely one-sided correlations. As muscle must "explode" it needs a quantity of explosible substances, viz. protein. According to the quantity eaten, meat increases protein surplus in diet and with it dyscorrelation because it lacks three vitamins and three mineral substances. Reliable information as to the effect of dyscorrelative diet may be obtained by studying the results of modern nutritional research.

How can we arrive at some criterion of the composition of a human diet with adequate correlations? General custom is no guide and no help here. Observation shows that even wild animals in captivity, as rats during nutritional experiments quickly get accustomed to faulty nutrition and even may prefer it to one that is healthy. Civilised mankind also has adopted the habit of faulty nutrition with serious consequences and without realising its errors.

The sole reliable guide is the structure of the feeding and digestive organs of the human body. Comparative

anatomy is decidedly of opinion that man is *frugivorous*, a fact which Cuvier already established. Richard Lehne says about this:—

" Far removed from the ever-changing, restless results of the research work of physiological science in nutrition, comparative anatomy supported by palaozoology and its documents, which are millions of years old, proves that human teeth in their ideal form evince frugivorous characteristics."

Consequently human nutrition with adequate correlations must be sought in the vegetable kingdom. There is ample reason to take this question seriously and to investigate it thoroughly. Its importance is proved by the therapeutic effect of such a diet as well as by the great injury to health that may be produced by dys-correlative nutrition.

II.—THE APPLICATION OF THE SECOND PRINCIPLE OF THERMO-DYNAMICS TO THE VALUE AND EFFECT OF NUTRITION.

Having attempted to view the essential nature of the organisation of food energy, we now proceed to consider the changes occurring in the original organisations of energy either naturally or through technical preparation. Two hypotheses based on natural science may be primarily assumed: (1) Every recognisable change in the structure of the substance of a nutriment signifies also change of its dynamic correlations. (2) All the alterations in a system of energies transpire according to the laws of thermo-dynamic theory.

My contribution to the first hypothesis is as follows:—

If Hackh's theory is correct, according to which the molecules of living substance are distinguished from the dead by light accumulation with a greater distance of valence electrons from the nucleus, transition from life to death signifies return of the valence electrons from the nucleus to their former more stable circuit, nearer to the nucleus with emission of light quants. Death therefore signifies loss of energy. It is most likely that this theory is correct since Telkes has proved that the electrical potential of the living cell disappears at death. In this connection may be mentioned that green leaves, if stored for several days, according to McCarrison, lose a considerable amount of their vitamin C contents. This may not be real death but the slow change of substance called " withering."

Whereas certain vegetable organs are often able to resist death for a long time, transition from the living state to death in slaughtered animals is brief, death proceeds irresistibly and is followed immediately by further decomposition. Proofs of this are: Disappearance of electric potentials, post-mortal rise of temperature, rigor mortis, formation of leucoptomaine.

It is well known that any change of substance through fermentation or putrefaction is accompanied by loss of energy. Less known, however, is the fact—important from the point of view of nutrition—that preparing food by heat induces profound alterations of the original organisation of energy. In the process of sterilising cow's milk the following constituents are changed: Fat (change in the capacity of cream formation), lecithin (destroyed because phosphoric acid is split off), casein (changes relation towards acids and rennet ferment), milk sugar (becomes caramelised), citronic acid (is

destroyed), soluble potassium salts (are reduced to an insoluble state), carbonic acid (diminishes), enzymes and vitamins (are destroyed), as well as the germicide power of milk which is destroyed by great heat. Through heat milk loses Schardinger's reaction, i.e. a redox-potential. The death of a great many infants from the painful Moeller-Barlow's disease has been proved to be due to the changed biological value of boiled milk.

Chemistry considers any substantial alteration of food by heat as an exothermal process which signifies also alteration of energy states.

The use of certain parts of the unity of a food-stuff is another kind of arbitrary alteration of organisation of food energy. An example will demonstrate this: In a wheat grain the nutritive factors are distributed in the germ, the grain coat, husk, and the endosperm, according with a plan : mineral substances here; vitamins, proteins carbohydrates there; fats, enzymes, etc., in another place. It is what may be called a biological-correlative organisation of energy for constructive vital purposes; as long ago as thirty years I spoke of it as a nutritional integral. By extracting, for instance, the endosperm to use it by itself as a nutriment, we supply the organism with but a fragment of the biological unit. Thereby the energy of the wheat grain becomes disorganised and the biological effect is definitely altered. Similar interference, regardless of biological and energic unities, is practised in various foods. I just mention manufacturing refined sugar, removing skin and core of apples, pouring off vegetable water, polishing rice.

Chemistry tells us a good deal more than I as a medical man can say about the inseparable unity of structure and energy and the various alterations of substance, including

nutritive substance. However, what has been said on the subject may suffice to arouse interest and to direct attention to its significance for nutrition. Neither the basic problem of biological-correlative organisation of food energy nor the transformation from its original living state until the food is ready for meals has yet been the subject of nutritional research. This neglect can no longer be justified in face of the serious alimentary ailments from which the great mass of civilised humanity suffers.

The changes in substance and energy organisation which the plant undergoes before it is usually held to be fit for human food are indeed manifold and various. The following may be cited:—

(1) Alterations through storage, drying, salting, smoking, and any kind of decomposition such as those which take place in transition from the living state to the dead.[1]

(2) Alterations through heat: Curdling, coagulation, swelling, caramelising, roasting, etc.[2]

[1] The conception that there is no effective difference between living and dead nutritive substances needs fundamental revision, likewise the notion that living foodstuff dies off on its passage through the digestive tract. Considering how infinitesimal molecules in "stimulated" condition are, a great many, if still alive, might easily reach the small intestines where light accumulation of the valence electrons might radiate forth to the intestinal epithelium, perhaps even to the blood which circulates in the intestinal capillaries. Are we really justified in ignoring this possibility? In addition compare to this: Kollath's paper "Vom Leben ohne Sauerstoff und von der Bedeutung des Sauerstoffungesättigten Zustandes des Protoplasmas," *Klin. Wochenschr.*, 14 Jahrg., No. 51, 1935, where he especially discusses anaerobe processes in the intestines.

[2] That heat has a prejudicial influence on nutriment is more and more recognised, as is shown by the following passage from an extremely interesting book by W. Ziegelmayer, "Unsere Nahrungsmittel und ihre Veränderungen" (published by Steinkopff, Dresden

(3) Alterations through disorganising ways of preparation.

(4) Alterations in eucorrelative harmony of composition of food.

The three alterations previously mentioned accompany the last mentioned. They form, however, special categories as well. If the assumption is justified that according to his physical structure man should confine his nutritional needs to the vegetable kingdom in order to ensure eucorrelation of nutrition, any transgression endangers the correlative equilibrium.

Even the use of cow's milk and eggs in human food may become dangerous, although they are excellent nutriment if of good quality and taken fresh and uncooked. The accuracy with which milk is naturally adjusted to the rapid growth of mammalia is well known. Therefore the addition of milk in increasing quantities is incongruous with the correlative needs of the human organism and leads in the course of time to allergic and other diseases. The effect of hen's eggs is probably similar; physicians are well aware of the injurious effects they may produce on the human organism. As an illustration I mention increased putrefaction of protein in the large bowels and the idiosyncrasy against eggs often met with.

and Leipzig, 1933): " The uncooked state safeguards some nutritive substances, prevents denaturalising protein, preserves primary mineral substances in optimal concentration ! Cooking certainly interferes with the colloidal stage of nutriment: cooking destroys high molecular compounds, alters the combination of the various molecules, surface tension, the degree of dispersion, osmotic tension, degree of dilution, coarse colloidal and molecular disperse conditions, hydrophil and hydrophobe faculty of colloids, it alters viscosity, reduces potentials. The stronger all forces remain in their mutual activity (i.e. not torn asunder) the greater is their power formation, the higher their prospective value." Rubner says: " the more unaltered substances enter the body, the greater the probability that they fulfil their physiological task."

It is true the disturbances of correlative equilibrium produced by these two items of food must have reached a somewhat high degree before notifying themselves so obviously. However, comparison with Nietzsche's simile about thought may be allowed: An idea that becomes conscious is like a volcanic eruption. Many a thing might precede such an " eruption " of thought which remains unconscious although not meaningless. As a rule a long series of repetitions of the same dys-correlative stimuli may be needed—a long incubation so to speak—until disturbances of health become tangible and perceptible. How rarely is it indeed possible to discover the causal connections, even in cases with marked symptoms ! But although hidden from our knowledge they cannot be treated as non-existent. The diseased organism offers the best opportunity for more subtle observations. The experience of Dr. Bienstock might be brought to the reader's notice: Dr. Bienstock suffered to such an extent from an allergic animal-protein toxicosis that he even had an attack after a meal prepared with part of the yolk of an egg.

Accurate observation of such subtle interferences with ideal correlative nutrition meets with almost insuperable obstacles in the complexity, i.e. excessive or great number of factors operating in the same direction in the so-called " mixed " diet of civilised people. Products of white flour, refined sugar, milk, eggs, common salt, are coupled with meat. A synergism of interferences is produced and resulting pathological conditions can hardly be discerned as effects of any one factor.

Meat is a powerful mischief maker, the part of which in pathogenesis is not yet sufficiently appreciated. Certainly it contains nutritive values, serviceable energy,

grades of redox-potentials. By far the greatest part of the strength of the meat is derived from energy organisations of the vegetable kingdom. Only a very small portion is due to absorption of light by the animal body. The whole energy reserve, however, is remodelled, which signifies that the correlations of the systems are displaced and adjusted to the structure and working plan of animal organs and tissues. As already stated, the correlations in meat, however, differ widely from that which the human organism in its totality needs. Over-emphasis laid on protein involves lack of vitamins and mineral substances.

Food energy, therefore, has always one and the same origin, whether it is derived from the vegetable or animal kingdom. In either case its source is light, absorbed by plants. But its organisation becomes different in the animal tissue. When served as meat at meals it has undergone still further changes, as the laws of energy testify.

What has been said about the probability of interference effect through food consisting of milk or eggs applies to a still greater degree for meat, its correlations having been transformed. Some idea of the pathogenic effects of meat diet may be obtained from examples such as acidosis studied by Katase and his pupils, the English physician Alexander Haig's remarkable clinical observations, Chittenden's conclusions as to the relation between meat diet and rheumatism, and last but not least, Bienstock's allergic animal protein toxicosis.

The difference between vegetable food energy and animal lies not so much in the nature of this energy, for it is light quant energy built up in plants which is utilised by the human organism. The difference lies, above all,

in organisation or transformation respectively, which manifests itself in the correlations of the nutritive factors.

I foresee great resistance and many refutations to the new doctrine, which will be challenged also on account of its novelty. To conceive food energy as systems of light quants is revolutionary enough. Still more unheard of is the conception of a specially schemed organisation of energy in every nutriment, which I termed food integral. If I go so far as to assert that with food we introduce energy into our body corresponding to the body's structure which is adequately organised, or disorganised, or transformed, some physiologists will immediately arise and explain that it is all nonsense, that in the process of resorption of food the digestive-fermentative action destroys the energy organisation. To quote Bickel, e.g.:—

" In the process of nutrition apart from some isolated exceptions the animal as well as the human body to a considerable degree destroys with digestion the energy accumulated in food especially in plant nutriment and through its own force it builds up new energy out of the ruins."

" Thus the prodigious sum of energy which has undergone changes in the marvellous workshop of the fresh plant never reaches the inmost bodily ' milieu,' but is to some extent just puffed away so to speak in the intestinal tract, with the exception of minute quantities of accessory nutritive substances."

These objections emanate from the purely material way hitherto obtaining of considering nutritional and digestive processes. Do they really refute my doctrine ? I do not think so because they contain actual objective mistakes which intrinsically weakens the argument.

According to Bickel the animal and human body accomplishes curious things: " it thoroughly destroys energy deposits of nutriment and through its own power it builds up new deposits out of the ruins." It is beside the question to consider the transformation of starch into glucose, the saponification of fats, and possibly the splitting up of the protein molecule in the bowels " destruction of energy-deposits to a high degree " ; whereas it must be clear that all the energy set free by the digestive process immediately forms part of the organism and is made use of by the latter. Carriers of energy may be destroyed; energy, however, is indestructible. The notion that " highest forms of energy are to some extent *puffed* away in the intestinal tract "—that is presumably disappear without leaving any effect—is utterly grotesque; it contradicts all that is known to natural science with regard to energic occurrences.

Still more astounding is the assertion that the body " builds up new deposits through its own forces " out of the ruins. *Whence* come these " forces " in the animal and human body with which energy systems can be built up (instead of the deposits) and which afterwards enable cell substance to emit light? No energy can come from nothing, according to the law of energy. To charge—*scilicet verbo*—an energy system, energy current is needed. The vitality of the human and animal body is mainly sustained by *one* source of energy only, that which is supplied by nutrition. Without it there is no " own force."

We must endeavour to abstract essentials from multitude of confusing material details in order to recognise nutriment as organised light energy and the process of nutrition and digestion as energic processes; or otherwise

realise those details as part of one supreme energy process. The number of intermediate processes is immaterial, the total energy alone counts which is liberated in the process of food being turned into waste matter. And the totality of this free energy is that which becomes the working energy of the body.

What Bickel regards as new " building up " of energy deposits by the body's own forces seems to me to be the beginning of transformation on the specific lines of the principle of organisation in the human organism.

Experimental nutritional research and innumerable observations in disease and restoration of health gave me ample opportunity to think matters over, and the conclusion to which I came is that food introduced into the body not only affects it by the totality of free energy in the form of systems of light quants, but also through its organisation, that is through the correlative structure of the energy factors to be found in the nutriment as a *whole*.

No one can appreciate more than I do the systematic, careful experimental study of problems of nutrition in higher animals and men, seeing that for decades I have watched the results with close attention; however I do not allow it to become predominant as do some physiologists. The new era of nutritional research has shown on the one hand how far from life and health-problems experimental research remained before the second decade of our century, and on the other how inconceivably complex, diverse, and unmanageable, those questions appear to the worker who probes their depths. Systematic, continual observation of a vast number of patients by an expert in nutrition achieves, in my experience, as valuable results—sometimes even more

valuable as regards practical life—than laboratory experiments. Indeed during my career I have often regretted the lack of personal medical experience and observation unhappily obvious in the case of some physiologists and experimenters. In spite of heartfelt recognition of the accomplishments of experimental research, I regret and am constrained to repudiate the ill-founded pretensions of some workers in regard to the physician and the disdain with which his observations and ideas are treated. At times I found myself in the situation: nutritional expert contra physiologist, and I most ardently wished that fifty patients with similar nutritional diseases should be handed over to each of us. If this experiment could be carried out, it would speedily show which is more efficacious.

So far the structural changes of nutritional substances in transit from the original condition until becoming dishes ready for table have been discussed, together with the various alterations in their several dynamic states inseparably bound up with those changes. We have now to consider the laws of energy with regard to the alteration of dynamic correlations, or the energy systems of food.

THE LAWS OF ENERGY IN RESPECT OF ALTERATIONS IN THE SUBSTANCE OF FOOD AND IN THE NUTRITIONAL PROCESS

It may seem presumptuous if I, as a physician, venture to write on the laws of energy and their working in such a mysterious process of life as nutrition. Not without reason the twelfth commandment might be cited: " Thou shalt not speak of subjects that thou dost not under-

stand ! " Indeed, with regard to physics there is much which is hard for me to understand and still more that I probably hardly understand sufficiently. I am always looking forward to one of the great physicists making it his task. It is true, whenever I addressed myself to one of our physico-chemists I got all the information required ; in regard to the problem of nutrition, however, they only said: It is outside my department. But as my observations of patients treated by diet urgently needed some explanation I was forced to find the way by myself. With the help of scientific lectures and scientific periodicals I studied theoretical physics, chemistry energics, atomic physics, theory of quants, etc., and applied the newly gained knowledge to problems of nutrition. What I found served as guide for my dietetic work, and as so many patients profited by this I felt in duty bound to communicate it to others. So far as I myself can judge I would say that on the whole the conception is correct, whereas the manner of presentation leaves much to be desired. May it induce the experts to come to the assistance of the physician, completing what he has begun. In physics the difficulty is that where ordinary ideas fail, mathematical formulæ are substituted which we are not always able to follow.

The quintessence of the preceding pages is that nutriment is not " matter." We now regard it as energy of a special kind and organisation. The human body is its sphere of action. It, too, has to be considered a highly organised, " stationary framework of energy " (Ostwald) continually consuming and absorbing energy. Rubner investigated the laws of energy consumption in nutrition. Consumption does not signify disappearance, but transformation into different forms of energy, mechanical

and chemical, and into warmth. However, all these processes are carried out in accordance with the laws of energy, and therefore their application to nutritional and life processes may reveal their secrets in an unparalleled fashion. Therefore let us now turn our attention to the chief of these laws, the first and second principle of energy.

THE FIRST PRINCIPLE

Law of the Preservation of Energy

"This law should long since have been common knowledge even of the ordinarily educated person, since even the most elementary textbooks give it and it is taught in all schools. Also clear presentation and understanding of this law do not present the slightest difficulty" (Chwolson).

Every physician is familiar with the law of the preservation of energy. He knows, too, that we owe its discovery to Julius Robert Mayer (1842), a physician, and its elaboration to Joule (1843), the English brewer, and Hermann Helmholtz (1847). Max Planck wrote a Prize Monograph on this principle (1887, 3rd edition, 1913). Helmholtz still termed it "principle of the preservation of strength," although Thomas Young had in 1807 introduced the term "energy" for the vital strength of a working body. The following fifty years of the nineteenth century established this term as expressing the difference between Newton's conception of strength and that which is now termed energy.

"Only one example: When a satellite rotates in a circle around a body, strength is continually affecting it, but no work is performed thereby and the potential

energy of the two bodies remains unaltered. The further two mutually attracted bodies are from one another, the greater is the energy and the less the strength with which they affect each other " (Chwolson).

Energy is somewhat different from strength and is connected with what is called " work." " Whatever is capable of performing work," says Chwolson, " possesses work-capacity or energy," and proceeds to formulate the meaning of the first principle as follows :—

" Whenever work is done it is at the cost of energy; the result of work is to generate an equivalent supply of energy in another form. The amount of energy contained in a closed system remains constant."

A system is said to be " closed " when it performs no external work. If a system performs work within another system or several others, it may be comprised in a new collective system with which it works or has work done, but this may again be a closed system. The principle that the content of energy remains unaltered holds good, too, for such a combined system. All the processes enacted within a closed system, however complicated its composition may be, do not alter its total provision of energy; this applies equally when manifold transformations of energy take place within it. In this wise the closed system's size may be extended until it comprises the whole of the known physical world. Thus it may be stated that the energy supply of the known physical world is constant and unalterable. Accordingly Planck defines the meaning of the first principle.

" The total energy of an externally closed system of bodies is a sum which no processes enacted within the system can either increase or diminish."

Hence in the known physical world there is neither

growth nor disappearance of energy. Therefore a system which performs continual work externally without becoming exhausted—a kind of *perpetuum mobile*—is utterly impossible.

When a system performs external work, its energy supply is gradually exhausted. When it reaches zero every work actually ceases. This system can only continue to perform work if fresh energy is given to it in the same proportion as it has been consumed. For instance the flame of a candle is a system continually exuding energy in the form of light and heat. At the same time it receives continually fresh energy from the oxidation of stearins with oxygen. Ostwald terms this kind of working systems " stationary fields of energy."

All living beings are such " stationary fields of energy " including the human organism, but the latter is able to create its own replacement of energy.

As early as 1845 Liebig vigorously defended the principle that the warmth produced by an animal body is completely provided in a direct way by the combustion of foodstuffs (Planck). We owe the strict proof of this relation to the calorimetric research of Voit, Rubner, and Atwater. The first principle of the theory of energy was thus proved to hold good for animal and human organism.

If we transform the human organism's entire working activity into warmth and measure this warmth production in a calorimetric cabin, the result will be a high degree of harmony between it and the warmth of combustion of the food consumed by the organism during the experiment.

Considering the various sources of error possessed by

this method of reckoning, only an approximation of the two caloric measurements was to be expected. Among these sources of error we must include the fact that in Berthelot's bomb the combustion warmth of food can only be measured if the food be dry or pulverised, not in its natural state. It is too often forgotten that drying or pulverising substantially reduces nutritional value. Nevertheless the harmony of the amount of warmth produced by the body and the combustion warmth of food is so great that there can be no doubt as to the validity of the principle of the preservation of energy.

This discovery made a great impression, viz. that the nutritional process could be calculated by a law valid in the inorganic world, i.e. by the first principle of the theory of energy. New signposts were hoped for with fresh practical consequences to follow. Thus the standpoint was reached that everything necessary was known about the intake of food energy by reckoning the calories required according to a person's weight and work with corresponding division of the food into protein, carbohydrates, and fat. The combustion warmth of foodstuffs as measured by Berthelot's bomb became the standard of comparison for food energy in general. This completely disregarded the fact that the caloric value of food is no indication of its nature, organisation, and the potential effects of the energy to be consumed. Patients were even given dietetic treatment by calories, a method the results of which were at least disappointing. Strange to say this was considered scientific !

Nowadays we are forced to recognise that the first principle is valid for the stationary field of energy of the human organism, but by no means suffices to explain the

energetics of the process of nutrition. Future generations will think it extraordinary that for more than half a century medicine could have remained content with the purely caloric outlook.

The first principle of the theory of energy only refers to the relation " in which the *quantities* of the different energies stand to each other when they transform themselves mutually. But the law has nothing to say as to when such transformations occur nor as to the magnitude they may reach under certain conditions " (Ostwald). What energies are transformed into quantities of warmth measured by calorics at the end of the process of nutrition ? We know that they are food energies which are summarily described as chemical. But does that really suffice to decide vital questions ? The amount of calories informs us how much energy will ultimately leave the body's system as the result of transformation. But it tells us nothing about the effective capacity which is introduced through the energies of food. Let me quote Wald :—

" The effective capacity of energy must be clearly differentiated from the amount of energy. This effective capacity cannot increase but it deteriorates, becomes exhausted, is ruined."

In order to establish the effects of food on the living organism, we must ascertain the food energy's effective capacity. This, however, is a result of organisation, of altitude of fall, and of direction. The law of the preservation of energy does not enlighten us about such matters, so we turn to the second principle which for thirty-five years I was alone in applying to the process of nutrition, although latterly Kollath has done so too.

THE SECOND PRINCIPLE

The Law of Entropy

" *The second principle of thermo-dynamics* sometimes called the *law of entropy* is a most interesting example of a magnificent discovery which did *not* comply with the conditions set forth above—in immediate practical applicability, exciting astonishment, easily understandable—therefore remained totally unknown to a vast number of educated people " (Chwolson).

A French artillery lieutenant, Sadi Carnot (1824), laid the foundations of this principle, additions being made by Clausius, Lord Kelvin, Gibbs, Helmholtz, Duhem, Planck, and Boltzmann.

The second principle is the law of direction of what happens in the physical world. The first principle holds good equally whether the happening occurs forwards or backwards, on the right or the left; the second principle states that happenings can only result in one direction. It speaks of the meaning of the occurrence, as Eddington says:—

" We have to appeal to the one outstanding law: the second law of thermo-dynamics, to put some sense into the world. It opens up a new province of knowledge, namely, the study of organisation; and it is in connection with organisation that a direction of time-flow and distinction between doing and undoing appears for the first time."

The second principle is concerned with the existence of order and organisation in the world of energy as well as of disorder and disorganisation; stating that what happens tends to go from order to disorder, from organisation to disorganisation; that in two states of the

same system the one that has the greater disorder is the later one; that wherever a state of greater order is created or of higher organisation this can only occur as a consequence, i.e. through the disorganisation of another system of equally high or higher order, if that state of higher order is maintained. There are therefore two kinds of processes: those which simply use up existing organisation whereby through loss of organisation a system of higher order passes into a transformed state of energy of a lower order; secondly those in which systems out of a lower organisation are transferred into states of higher organisation at the cost of the organisation of other systems. The first kind of processes are voluntary, natural, or positive; the processes of the second kind are involuntary, unnatural, or negative. Chwolson states:—

"Closer consideration of this and other processes shows that we must divide all conceivable and practicable processes into two groups. In the first group processes occur spontaneously and literally "of themselves"; they appear continually all around us. To these belong the transition of heat from a warm body to one that is colder, the generation of warmth by performance of work, the natural diffusion of two gases, the dissolution of a solid body in fluid, etc. We may designate this group of processes as natural or positive. The characteristics of the second group are quite different. Among them are those opposed to the natural and positive groups, e.g, transmission of heat from colder to a warmer body, the assumption of warmth for the performance of some work, etc. Such processes may be described as unnatural or negative. It will immediately be realised that such processes never occur of themselves in the

usual sense of that word. But that is not vital: the crux of the matter lies in the following indisputable fact. Unnatural or negative processes may of course be brought about by suitable manipulations. But it is impossible to discover manipulations which make the negative process to be the sole result of manipulation. The negative process always and immediately proves to be accompanied by a positive process. Hence while positive processes in Nature may appear " solo " those which are negative must be simultaneously accompanied by positive:—

" In general it may be said that the unnaturalness of a negative process is compensated simultaneously by positive elements. Obviously such compensation is determined by quite definite quantitative laws, viz. that the positive process must possess a certain magnitude in order to make the negative one possible, i.e. its compensation.

" Let us generalise what has been said by examples. There are in the world two kinds of processes: positive which always and everywhere transpire in desired quantities and negative processes, the opposite of the positive, which must be accompanied by positive ' equivalents ' of equal size. And here is the essential point.

" One definite tendency governs the processes of the world we know, without exception they all happen in a definite direction. If we regard every positive process as figuratively a forward step and every negative process as a step backward, we might say that any quantity of forward steps may happen, but that every step backward must be simultaneously accompanied by a forward step of equal size. Hence there is no backwards ! Only a striding forward or—eventually standstill."

Natural processes pass from energy states of high organisation to those which are lower, from order to disorder. " Of themselves " no reversed process exists. *Every voluntary positive alteration of state of any energy system is inevitably accomplished by loss of organisation or of order-value.* This logical conclusion resulting from the second principle applies too to every altered state affecting the energy systems and organisation of food or —which amounts to the same—food substance or foodstuff laden with dynamic correlates.

Entropy was Clausius' (1865) term for the measure of disorder, of disorganisation resulting from the natural process of an altered state. Obviously " free energy " is the opposite state to the entropy of a system. Helm informs us: " Processes arising of themselves are those which lead the system from a state of greater free energy to one of less." Entropy increases under the same conditions as the free energies of a system decrease.

Just as in the foregoing we have extended the idea of the system to the whole of the known physical world, we may now also apply the second principle to that world. We thus see that the entropy of the physical world increases continually, whilst its free energy decreases correspondingly. This interpretation gave rise to the phrase " heat-death of the world," and it is psychologically understandable that great resistances to the law were aroused by this deduction from the second principle. It was relatively easy for those resistances to arrest the spread and penetration of the new knowledge, because great obstacles to the reasonable understanding of the concept of " entropy " resulted from the phrase " law of entropy," which was commonly used. Helm says:—

" The difficulties of the entropy idea are so considerable that every attempt to overcome them deserves attentive consideration."

Eddington terms the entropy " an artificial mathematical symbol," and adds " that something inconceivable must lie at its base."

" Setting aside the guidance of consciousness, we discover a signpost for time in the physical world itself. . . . Take an isolated system and measure its entropy at two instants t_1 and t_2; the rule is that the instant which corresponds to the greater entropy is the later. We can thus find out purely by physical measurements whether t is before or after t_2 without trusting to the intuitive perception in our consciousness of the direction of progress of time. In mathematical form the rule is that the entropy S fulfils the law

$$\frac{ds}{dt} > O \text{ i.e.}$$

dS/dt is always positive.

This is the famous law of Thermo-dynamics."

Planck sees a dimension in the entropy which grows with every non-reversible process. He says:—

" Every physical system in every state possesses a definite entropy and this entropy indicates Nature's preference for that particular state."

Boltzmann deduces the idea of entropy from the probability idea. Nature only makes transitions in the direction of greater probability. He says:—

" Every physical and chemical alteration of state transpires in the medium so that they increase probability. . . . According to its content the entropy principle is a theorem of probability, at bottom it only asserts that a more probable state always follows one

fundamentally less probable within the medium." Adding to these definitions of the second principle he says, " For what is disordered, usual, common is fundamentally more probable than what is ordered, excellent, distinguished."

These definitions and statements show the great difficulty of finding a way of expressing the law of entropy that is easily understood. I am under the impression that the matter is attacked at the wrong end. May it not be that the entropy is the refuse to be expected from energy's performance of work? A city has a definite measurable amount of refuse upon which the laws of its consumption may be calculated. This refuse is the most unavoidable and probable part of its existence, traces of which often linger for centuries. Nevertheless the vital processes of the city's life are not defined with any degree of lucidity by the theory of refuse. It seems to me that this way of regarding the second principle has hindered the non-physicists from perceiving its enormous significance.

Let us see what Eddington has to say about the second principle:—

" Our attention must be fixed on two things: on *energy* and *organisation of energy*.

" Whenever anything happens which cannot be undone, it is always reducible to the introduction of a random element analogous to that introduced in shuffling."

Chance happening is the contrary of organisation.

" Any loss of organisation is equitably measured by the chance against its recovery by an accidental coincidence.

" The practical measure of the random element which

can increase in the universe but can never decrease is called entropy. Measuring by entropy is the same as measuring by the chance explained in the last paragraph, only the unmanageably large numbers are transformed (by a simple formula) into a more convenient scale of reckoning. We can, by isolating parts of the world and postulating rather idealised conditions in our problems, arrest the increase, but we cannot turn it into a decrease. That would involve something much worse than violation of an ordinary law of Nature, namely, improbable coincidence."

To quote Eddington, the entropy appears to be " the practical measure of the chance element in the universe." This element of chance in the world in itself implies a more or less slight probability, so that some degree of organisation might arise or reappear through the accumulation of chance occurrences. Eddington illustrates the greatness of the contrast between this probability and the second principle by the following quaint simile:—

" If a herd of monkeys were strumming on typewriters they *might* write all the books in the British Museum."

That signifies the utmost improbability. Its opposite, the utmost probability, belongs therefore to the validity of the second principle. Hence Eddington says:—

" When numbers are large, chance is the best warrant for certainty."

It seems to me that the most important point in the second principle is not the entropy but the existence of an organisation of energy. There would be no entropy if no organisation existed, seeing that this is the measure of disorganisation. Therefore I am inclined to term the

second principle " the principle of organisation " or " the principle of disorganisation," if we prefer to look down rather than up.

Looking downwards, an endless increase of entropy is seen; looking upwards, on the contrary, the continually increasing organisation of energy. Hence Eddington writes:—

" Travelling backwards into the past we find a world with more and more organisation. If there is no barrier to stop us earlier we must reach a moment when the energy of the world was wholly organised with none of the random elements in it."

In the first part of this book we have spoken of the magnificent ascending scale of this organisation of energy as presented by physics. The nucleus of the sun with temperatures of about 10 million degrees centigrades is at the beginning of this scale, together with inneratomic energy which such conditions release. The transition of this energy into rays follows, first X-rays, then light radiation of about 6,000 degrees centigrade. Transformation on the earth follows, the energy of water may be turned into clouds, rain, snow, into the vital power of rivers and avalanches, electrical energy, and above all become the organisation of energy in the phenomena of life which on their part are consumed by the activity of living.

This scale begins with a tremendous temperature which decreases at every successive step, transforming the light of the sun into light potentials and other equivalents in so far as the processes of life are in question and ends ultimately as disorganised warmth production of organism, depicting a grandiose decline of energy. Thereby organisation continually decreases, entropy increases continually.

In so far as warmth energy becomes an apprehensible phenomenon temperature, not the amount of warmth, is the measure of organisation. Hence Eddington:—

"As regards heat-energy the temperature is the measure of its degree of organisation; the lower the temperature, the greater the disorganisation." But also: "By warmth we understand the energy of unordered molecular movements."

As a matter of fact the energy of warmth is peculiarly differentiated from other kinds of energy. All the others may be changed into warmth without remainders, on the other hand the transformation of warmth into other forms of energy can only happen by losing part of the warmth-energy. It certainly seems to me that the dimensions of the loss decrease with increasing temperature, especially if one thinks of the million degrees of the sun-nucleus. Eddington states about this difference:—

"Quantitative the heat produced by impact is the exact equivalent of the lost energy of motion of the body as a whole, it has a less organised form. Nature keeps strict account of all these little wastages of organisation which are continually occurring; each is debited against the total stock of organisation contained in the universe. The balance is always growing less. One day it will be used up."

Whilst temperature is the measure of the degree of organisation of energy, it is also a measure of its working capacity, i.e. of its power and intensity. Under all practical conditions working capacity increases relatively with the temperature, with the intensity factor of heat-energy. Nothing can be stated about the working capacity of a quantity of water, however large it may be,

if the temperature is not known. Under given circumstances no work can be done by the enormous quantity of warmth contained in the ocean because its temperature is too low. Similarly, no conclusion can be drawn from the amount of calories produced by animal and human organisms as to the working capacity of the food-energy taken, because the amount of calories does not give us any indication as to the intensity factor of the food-energy. Therefore it is not an adequate measure for the energy needed by the organism.

That which temperature is for heat-energy, exists too for every other form of energy. In electricity the intensity factor is measured by watts, in the energy of position by the altitude of fall, whilst the energy of light is first indicated by the frequency of oscillation of the light quants and then through the intensity of the local radiation of a light source at a given distance and a definite temperature.

Chemical energy also has its factors of intensity or potentials, only they are hardly available for direct measurement. The potentials of chemical energy result from the position of valence electrons in the various energy levels of atoms and molecules, or chemical systems of energy. Intensity factors or potentials of chemical energy arise in reduced systems through the process of reduction, the effects of which become identified as soon as the systems are again ready for oxidation. Potentials which arise through reduction and are used up by oxidation are termed redox potentials. Being phases of reduction they are able to reduce phases of oxidation, so that their strength may be measured by their capacity of reduction.

Just as the temperatures of heat-energy the chemical

potentials in redox potentials fall and rise. The rise is described as " becoming more negative," the fall as " becoming more positive." Working capacity increases with negativity and lessens with its decline.

As the constructive processes taking place in plants through light absorption are to a large extent processes of reduction, they naturally lead to the formation of strong redox potentials, figuratively speaking to high chemical temperatures. These are the forces of energy or *potentials* which are peculiar to " natural fresh " plant organs including those which are suitable for human food.

With the transformation of one form of energy into another, factors of intensity are also transferred. The temperature of a source of light is transferred to the intensity of the light radiated which can be defined by the spectrum. The intensity of the quant-jump of valence electrons (chemical energy) passes into the frequency of the light quant thereby emitted, and vice versa.

In absorbing the electrons a given light quant can only raise its frequency to a corresponding level of energy. Hence it may be stated that the intensity of the form of energy resulting from transformation cannot be higher than the intensity of that form of energy the transformation of which produced it. But if work is performed at the transformation, the intensity, the potential of the new form of energy resulting will decrease correspondingly.

Here we must recall what was said above about natural or positive processes and those which are unnatural or negative. The reduction processes occurring in the plant are unnatural or negative processes, which can only take place accompanied by positive processes, in this case by absorption of the energy of light. The

intensity or potential rise experienced by the chemical energy afterwards expressed by the redox potential can, according to that statement, not be greater than corresponds to the reciprocal height of the light intensity. The resulting intensity of chemical reduction phases may therefore be equivalent or lower but never higher, seeing that the intensity of sunlight (6,000 degrees centigrade) is proportional to the temperature of the source of light, the maximum light of the resulting redox potentials cannot surpass the equivalents of these intensities. But since this transformation of light energy into chemical energy happens through the transference of light quants into energy levels of valence electrons, it is possible that the height of the rise in the redox potentials may, at least partially, reach the equivalent of the intensity of light.

We thus gain some slight idea of the intensity of energy, i.e. working capacity, introduced into the human body by such a diet of natural fresh plants.

To a very limited, almost minimum degree, there are also negative processes by light absorption in animal and human organisms which doubtless are of equally great energic significance for processes of health and life. To these belong the formation of vitamin D out of its preparatory stages through insolation and ultra-violet radiation of the skin and the formation of pigments to the significance of which too little attention has hitherto been paid.

Energy intensities of animal and human organisms are, however, to a tremendous extent derived from organisations and redox potentials of plant diet, thereby their reduction capacity with the help of redox systems (vitamins and other catalyzators as glutathion) is also used for further reductions, i.e. for potential raising of

systems which have lost potential height and through increasing oxidation have become more positive. It should be quite clear that a potential raising through the transformation of vegetable food into animal body substance is as improbable an occurrence as the writing of British Museum books by a herd of monkeys banging on typewriters. This realisation should finally dispose of the fable of the "strengthening" power of a meat diet. It seems to me that we must come to the conclusion that even the substances of living animal organs and tissues represent a mixture of energy systems which contain a considerable amount of positive elements as well as high redox potentials. After the animals' death struggle a far-reaching increase of weakened systems in the potentials must be assumed to which every muscular cramp contributes. A fundamental difference between natural fresh vegetable and animal diet thus becomes evident, which undoubtedly is not in favour of the latter. Also we must not forget that we have already come across another essential disadvantage of meat diet: the disorganisation of correlative equilibrium in a balance of tissues which is not adequate for the needs of the frugivorous human organism.[1]

[1] I know these valuations of meat diet will not be accepted by many. Prejudice in favour of this food holds medicine also captive. But I cannot curry favour and must say what deep reflection and forty-five years' study of disease and recovery have taught me. I am well aware of the objections raised against my "one-sided and extreme" views by the upholders of traditional diet and also know the contravening facts; Eskimos and Vilhjalmur Stefansson and the like. But I also know what their refutations are and the appalling short-sightedness with which problems of nutrition have been treated in hospitals and physiology alike, greatly to the disadvantage of civilised humanity. And finally I am aware that not only human frailty but many and powerful interests oppose the revelation of the truth. Those who have searched untiringly and dared to change their own diet may agree with me; not those who have no such experience to back them.

But what of the manifold alterations undergone by food from its original state until it appears upon the table? Judged by the second principle these changes are consequences of natural positive processes. That is a significant fact. Energy systems pass often successively from State A into States B, C, D, etc. Compared to the previous state each successive state shows a loss of order, organisation, and level of potentials, but a gain in entropy or disorder.

This applies to every alteration mentioned above, to withering, drying, all after-death processes, to all alterations produced by heat, graded according to the temperature and duration of the influence. The fact that at death the stimulated states of the molecules of living substance emit their quants whilst the cells' electrical potential falls to zero signifies the first loss of energy and potential. Figuratively speaking, the second concerns the temperature of the redox potentials which fall therewith. Food suffers a great loss of biological-energic organisation, which is all the more important for its nutritional effect because in all probability especially effective energy values are included.

It may be objected that—however logical my conclusions may be—the facts they are based on are mere speculation. Neither I nor my critics have measured the loss of energy and potentials nor the increase of entropy, neither are we in a position to do so.

Nevertheless my conclusions are derived from indisputable scientific facts, which inevitably result from the application of the second principle. The far-reaching significance of this principle having been realised and accepted, it logically follows that all these alterations of food which arise through processes occurring " of them-

selves " really are squanderings of order. The fact that hitherto the science of nutrition has disregarded all such wastings of order was an error, but not a reason for doubt or dispute. It must not be forgotten that " Nature keeps strict account of all such continual small wastings of order." But in this case Nature is human nature, its health and working capacity, as my forty-five years' experience of sick people has abundantly taught me.

The unique advantage of the second principle is precisely that it is possible to " apply this method of research to regions in which we have only just succeeded in lifting a tiny fraction of the enveloping veil " (Eddington). The following extracts will show the great significance attached to the second principle by those who know it best:—

Eddington: " The law that entropy always increases —the second law of thermo-dynamics—holds, I think, the supreme position among the laws of Nature."

Chwolson: " I maintain that the discovery of this law is the human spirit's greatest achievement in every branch of science. That the basic thought of this law is incomparably fertile and full of promise in philosophic depth and of all-embracing significance for the recognition of the facts of existence—no science can put forward any thought, any result which equals the entropy principle in grandeur. Humanity may be prouder of this principle, bearing the stamp of the beauty of absolute truth— than of anything else which it has attained, seeing that almost everything else is either debatable or true only to a limited extent. Among the few real truths striven for and attained by humanity, the law of entropy is first."

" Moreover the second principle and the theory of entropy must not be regarded as two principles which are

absolutely identical. There are many different kinds of formulations of the second principle, one of which deals with the entropy and as its elegant form and verity appeal to the specialist, the second principle is simply termed the entropy law. It is, however, quite possible to explain the nature of the second principle, without mentioning the entropy."

" The entropy law is incomparably the most powerful instrument which physics possesses for the search for the secret laws often undreamt of which govern physical phenomena. Since it holds good for all phenomena it may be used for the analysis of energy phenomenon, and so has been and still is used. Unbounded and inestimable is the quantity of new light science has acquired by the help of the second principle of thermo-dynamics.

" Of the three great fundamental laws of physics (preservation of energy, preservation of matter and the second principle of thermo-dynamics) the third is precisely the true law of substance in that it makes it possible for us to discover the most secret qualities of substance."

Everyone who is willing can see from these opinions how singularly significant the second principle is for each and every physical happening in Nature as we know it. To think that this law of Nature has been known since the middle of last century and that nevertheless even to-day physiologists do not yet apply it to the solution of nutritional problems, may well prove to be an astounding fact in the history of medicine. This extraordinary unwillingness to apply the second principle is further exemplified by the fact that it is thirty-two years since my first publication about this subject in

which the same conclusions as put forward to-day were briefly described (more fully in 1906 and 1909). Not only did my explanation meet with no understanding, alike from physiologists and university teachers, but they were treated disdainfully as mere mysticism. So it continued until at last in December, 1935, Prof. Dr. Kollath, in the Klinische Wochenschrift, supported me and my views. This event cannot be welcomed too warmly, seeing that it opens a path to medical science for the second principle the significance and implications of which are vastly important for problems of nutrition and of health. Hitherto medicine has disregarded this law of Nature, a state of affairs that must be changed. Life is a great energetic happening. Doctors must become deeply versed and familiar with energy, the organisation of energy, and its laws. In future Chwolson's words should no longer apply to the medical profession: "The law is almost unknown outside the inner ring of physicist-specialists. The reason lies in the great difficulty of penetrating deeply into thermodynamics and in the necessity for extensive preliminary knowledge."

The attitude of the medical authorities of that time gave abundant proof that they knew neither the content nor the significance of the second principle. Had it been otherwise they would not have remained satisfied with reckoning by calories in the problem of nutrition. Indeed they would have long been aware that the combustion warmth of foodstuff has only been measured in dried pulverised material, and that energically such a state is altogether different from that of natural fresh food. This "difference" may be unessential in the different combustion warmth but not in regard to the different state of order, i.e. of energy intensity.

The second principle which gives us " the possibility of discovering the most secret qualities of substance " asserts therefore that in all the altered states of food in question every later state will be poorer in organisation and intensity, but richer in entropy; this is so regardless whether our technical capabilities do or do not permit us to measure the difference. The variety and total number of altered states that human food passes through before it is ready to appear as a dish on the table, must be left to the reader to imagine and to realise.

I am chiefly concerned to indicate the significance both possible and probable of these altered states as it affects the human organism's consumption of energy.

The energy of food enters the stationary field of energy content of the human organism in a definite state of organisation and intensity. According to the first principle an equivalent amount of energy leaves the human organism but in a state of extensive disorganisation and with greatly increased entropy. Under normal conditions we may regard the end-state as a definitely greatly reduced energy level. For the moment end-states resulting from imperfect combustion due to pathological states are excluded from these remarks.

The energy-difference between the beginning-state of the food taken and the end-state in which energy leaves the body, indicates the measure of the total fall of energy with which the body works as an energy system. This fall of energy or potential is the force with which life processes work. We are reminded of Planck's phrase: " Newton's concept of power has been replaced by another higher and more embracing concept, viz. that of work, or of potential since power is generally defined as the fall of potentials."

Power increases with the altitude of the potential fall which works the life-process. This occurrence is exactly comparable to the altitude of a waterfall or the fall of the water conduit of some power works. The power depends therefore upon the difference of energy, differences of intensity between the beginning- and end-state of energy in its passage through the body.

Helm: "In order that something may happen there must be differences of intensity in the energies present." Ostwald: "In order that something may happen non-compensated differences of intensity must be present."

The presence of differences of intensity is termed by Ostwald "the necessary but not adequate condition" of the occurrence. In fact a dissolving factor is needed in order that the occurrence may take place, a factor of *disturbance*. In the living organism this factor is supplied in manifold forms through the activity of cell nuclei.

The vehemence of the occurrence depends upon the degree of intensity, or differences of the altitude or of the potential fall. Thereby the rule holds good that the total result of this occurrence is completely independent of the individual processes within the system through which power works from beginning-to-end state. That is to say that under normal conditions the digestive processes in the stomach and alimentary canal and the individual phases of metabolism cannot cause any difference in the total process of supplying the organism with energy. This point of view is in opposition to the conceptions of those who seek to reckon energy supply only from the chemical fragments of food excreted by the bowels.

The decisive point is whether the investigator sees food as substance and the process of nutrition as metabolism,

or as the organisation of energy, i.e. of energy " current." It requires great efforts to reach the latter view-point seeing that our thought to-day is directed to the material. As early as 1901 Ostwald wrote the following significant words:—

" In every living creature the *flow of energy* is a never-failing characteristic. Usually the process taking place is described as *metabolism*, but that word does not indicate the principal factor of the situation. It is by no means easy to perceive why continual substitution of substance of which an organism consists should be effected by other quantities of the same substance. Apparently it would be more suitable if the substance once formed were permanently to continue to be the creature's body, only perfecting itself by suitable growth. Instead of which we perceive that this better arrangement only applies to a few parts of the body, such as the bones in man, and the wood in trees, while the greater part of the body is subjected to continual metabolism, the rapidity of which undoubtedly differs greatly in the various parts of the body."

" As a matter of fact metabolism is only the phenomenon accompanying the energy stream. Seeing that organisms use chemical energy predominantly, the acquisition of which is bound to the transformation of substance, the necessity arises unceasingly on the one hand of removing those factors from the organism which have lost their energy supply, whilst on the other of receiving new supplies of energy in the form of matter only to experience the same fate."

" The circulation of matter has often been pictured on the one hand as carbon uniting with oxygen through nutrition and combustion whilst on the other hand it is

again separated from the oxygen in plants whereupon the two elements are enabled to resume their circulation. Correct as is this description of one side of the process, it does not touch the kernel of the affair. Actually this is not a question of circulation but a *unilateral flow* of energy pouring into the earth from the sun, it is used there partly immediately, partly stored up in plants in the form of chemical energy in order to continue to be used by plants and animals for the performance of their vital activity."

Processes of digestion and metabolism are accompanying phenomena of the energy stream which passes through the human body. What is determinative and significant is the stream of energy, viz. its constitution and strength on which the accompanying processes of metabolism and digestion depend and not vice versa. This energy stream is a fragment of the great cosmic current of sun energy, totally unaltered by the circumstances of its temporary transformation into the chemical organized energy of plants. In reality our vital functioning is joined to the sun's energy stream like an electric lamp to electric current.

Now we may return to the altitude of the energy current between the beginning and the end states of energy in the body's functioning. If in the end-state the level of energy is the lowest possible for the organism, corresponding to the energy's further complete unusability for its purposes, the increase of entropy will then have reached the biological maximum and that end-state might then be described as normal. For our purpose we will thus regard the end-state indicated.

Now the energy altitude, i.e. the vehemence of the occurrence in the body only depends upon the beginning

state, viz. upon the energy organisation of the food introduced. This statement leads us suddenly to the vitally important significance of the subsequent alterations alluded to above which food goes through from its original state until it is ready to appear on the table as a dish. Each reduction of intensity, every loss of organisation occasions a lowering of the energy altitude at the organism's disposal, therefore also a reduction in the vehemence of the occurrence in the body.

It is very probable that some of those alterations, e.g. after-death changes in muscles and the effects of great heat, deprive the energy systems of food of precisely the most valuable " peaks " of their levels of organisation, that is of their effective capacity in the life process. In every case we are taught by the facts of biological research in nutrition to be on our guard against the assumption that such squandering of order is of no significance, a view that has usually been taken hitherto. We should then be assuming something which conflicts with the second principle, and Eddington's words would apply:—

" But if your theory conflicts with the second law of thermo-dynamics I can give no hope; there is nothing for it but to collapse in deepest humiliation."

On the contrary, upheld by the second principle my observations of the processes of disease and healing all go to prove that these altered states cause an essential loss of organisation and intensity. Consequently, with the altered food the beginning-state of energy placed at the disposal of the energy altitude or power is substantially reduced. This must immediately become evident in the vital processes, in the vehemence of occurrences, in the purity of life's flame, in the completeness of " combustion " or oxidation, etc.

If one were to take away from a human organisation, e.g. a well-trained infantry regiment in good fighting fettle even only 10 per cent. of sight, hearing, and marching ability, the result in war might well be disastrous alike for the army and the nation. Similarly a performance of Bach's St. Matthew's Passion would be considerably damaged if the mixed chorus were to lose even 10 per cent. of the strength and purity of its tone.

In this sense I conceive the significance for the occurrence of vital processes of the altered states which food or foodstuffs usually pass through before they are ready for the table. Thereby the energy altitude between beginning and end-state can only be lowered, the vehemence of the occurrence reduced. Obviously all the processes of the several parts inside the system, including what we call metabolism, will suffer too, and finally also health. Figuratively speaking, the temperature of life's flame will fall, the light become dull, the flame sooty. If incomplete combustion results the level of the end-state will be raised, whereby further diminution of the altitude between beginning and end-state is brought about.

The logical application of the second principle to the energy value of food and the nutritional process leads to these conclusions. The food's loss of organisation results in a reduction of the energy altitude and therewith a weakening of vital processes. That signifies a loss of nutritional value or strength. And this loss affects man's functional capacity, constitution and health.

All the arbitrary alterations in the composition of human diet which I referred to above as deviations from natural frugivorous diet, and discussed in some detail, should be added to that loss of energy resulting from the

energy altitude and the altered states of food energy. I outlined my conception that these deviations signify injury to the biological correlative organisation adequate for human food, seeing that the natural balance between the chief elements of nutrition mineral substances, vitamins, etc., corresponding to the needs of the human organism, is shifted. It was also pointed out that the customary use of meat, white flour, white bread, refined sugar, blanched vegetables, greatly exaggerated use of cooking salt, must all be regarded as chief sinners in this respect.

I have come to the conclusion that there is a harmony between our body's need of correlations and the correlative composition of food intended by Nature, a harmony analogous to that between the mother's milk and the rate of growth of her suckling.

Since this, too, is a question of an organisation of food energy, a problem of order vitally important to life, and since this organisation likewise falls victim to disorganisation in the process of life, we are involuntarily constrained to realise that this process, too, follows the line of direction of the entropy principle.

Eddington leaves the question of origin open when he alludes to the completely ordered state of energy which once existed. He only remarks: "To order is the prerogative of reason and instinct." The biological correlative organisation of food energy and the synchronisation of the organism's needs are works of Nature so immeasurably astounding as to constrain us to see in them the working of a superhuman intelligence. All the more is it seemly for us to treat this organisation with respect. I have seen what a terrible price mankind has to pay and still continues to pay for this lack of regard.

I see a higher grade of the law of organisation or entropy in this biological correlative organisation of food so that the totality of organisation may be regarded as an all-embracing unity.

In this monograph upon " Potential of Oxidation and Reduction " L. Michaelis says cautiously:—

" Modest as the fruits of this chapter of physical chemistry may be for physiology, I would nevertheless venture to assert that these beginnings are destined to guide the theory of changes in substance and energy of living cells into a new direction."

This assertion only relates to the theory of redox potentials, which is an essential part of the problem of organisation. If, however, we enlarge our vision to embrace the total area of the organisation and disorganisation of the energy of food in the sense already described, new and practically important relations to metabolism result. The phrase " Nothing is more practical than a good theory " is here again verified. The following indications result from this theory:—

Metabolism comprises all the partial processes of the transformation or disorganisation of energy in the organism. These partial processes are influenced by the organisation of the food energy introduced, upon which the energy altitude between the beginning and end state of the energy stream flowing through the body depends, i.e. the power and vehemence of what happens. If the energy organisation of food is optimum and the human organism adequate, the greatest possible altitude will result and all partial processes be enabled to transpire normally, viz. metabolism is accomplished undisturbed. On the other hand every lack of organisation in the energy of food leads to a diminution of the altitude, i.e. to a reduction of nutritive power, to disturbances in the

course of part processes, thus also to disordered metabolism.

Every student of metabolism knows into what an impenetrable labyrinth the chemical-material investigation of the pathology of metabolism often leads, and how difficult it is to deduce directions for therapy from results thus assembled.

The second principle postulates that:—

(1) An organism which is permanently nourished with food deficient in organisation including inadequate correlations of energy systems (nutritive factors) must sooner or later lose metabolic equilibrium and become constitutionally diseased, despite individually various elastic adaptive capacities and manifold emergency regulations.

(2) An organism has the greatest probability of remaining healthy which is permanently nourished with food, the organisation of which is so far the optimum both with regard to biological energy and to correlates, that the limits of elasticity of adaptation are not exceeded,

If we know a man's permanent nutrition in respect to its total organisation, we are able to draw conclusions as to the probable course of his metabolism and the prospects of his remaining healthy. If a sick man is in question, his permanent nutrition gives a hint both in a positive and negative sense as to the part played by food in the ætiology of his disease, besides an explanation of disturbances in his metabolism.

These results from the application of the second principle are of the greatest significance for the physician's prophylactic and therapeutic actions. Katase's words apply here:—

" From the standpoint that food is the ruler of life and health, the first duty of medical research is the exact study of the influence of food, that is of nutritive substances upon the living organism. Only when the influence of the food consumed by man have been closely and carefully investigated, can their effects on the human organism be elucidated. Thereby a firm basis may be created for prophylactic measures whilst at the same time therapeutic indications are given."

In every disturbance of health in the ætiology of which nutrition plays a part—and where is that not the case nowadays?—the most efficacious health diet is food with the optimum organisation of energy and correlates. Always the same diet whatever the disease may be called and however variously disordered metabolism may be presented. Part processes can be ignored if we undertake to choose the food of optimal organisation and equilibrium.

Detailed suggestions concerning health may be found in my other publications, especially in an introductory paper " Fruit Dishes and Raw Vegetables," and in an article in the *Münchner Med. Wochenschrift* (1935, No. 13, p. 96). Adaptation to individual circumstances in various states and diseases is there discussed in detail.

The uniformity of health diet so efficacious in all diseases in which alimentary troubles play a causal part, is only stressed here in contrast to clinical tendencies hitherto prevailing. According to these a special diet was called for in every pathological anatomical disease, e.g. heart, stomach, liver, kidneys, etc. The pathological-anatomical product does not determine the choice of diet, but invisible dynamics out of which disease has ultimately grown, since according to the vulnerability

of the organs the most diverse anatomical-pathological configurations of disease may arise out of the same state of disorganisation.

It is, however, quite clear from what I have described that each fruit, every green leaf, each seed-grain, every organ storing reserve of the vegetable kingdom, possesses its specific organisation and therefore also its specific effective capacity. The different biological effects of these plant-structures as at present known only empirically or through pharmacology in so far as the latter is interested in herb and plant therapy, are based upon this state of affairs. Each kind of apple has a different effect, the effect of grapes differs from that of the cherry, strawberry from currant, cucumber from tomato, etc. No one doubts the existence of these different effects. Adequate scientific research has not yet tackled the matter. Here, too, the future may yet reveal manifold vistas.

Experience has proved the healing effect of a monodiet such as grape cures, greengage, strawberry, or lemon cures.

In the diet for diabetes, about which a further communication of mine will appear shortly, in many cases fruits which are rich in sugar should be avoided, the consumption of green salad and raw vegetable juice being increased and fruits poor in sugar preferred until tolerance has grown greater.

As a rule, however, it all depends upon the total composition of vegetable health diet, and in practical life the season and the possible supply of vegetable foodstuffs together with climate, country, and district, determine the changing constituents composing health diet.

Summary

The first principle of the theory of energy only makes negative statements about the energics of nutrition. It contains nothing, however, about the effective capacity of food energy nor its deterioration, exhaustion, ruin or degradation, either through alteration of the nutritive substance or in the working of the organism. It recognises no organisation of energy but also no disorganisation, states nothing about intensity, potential altitude, nothing about the direction of what happens, nor about the suppositions of possibility, the magnitude, vehemence of the event, nor about the relations between the chemical part processes of the total metabolism and the energy.

The calculation of calories only informs us as to the sum of energy flowing through the organism, but tells us nothing about its effective capacity. The combustion warmth of food and the total warmth production of the organism give us, figuratively speaking, the amount of water which has flowed down to the sea from the mountains, but this amount tells us nothing about the height whence it came and what could be accomplished by the flow. The amount of calories simply gives us a sum of energy which, being used up, has become disorganised, but it says nothing about an order once existent.

Nevertheless the energics of nutrition have hitherto only been treated from the standpoint of the first principle.

At the beginning of this century I realised that the entire problem of nutrition was dominated by the second principle of thermo-dynamics. From this I deduced a new theory of nutritional values as well as directions for the therapy of nutrition, which led to incomparable success in dietetic cures. My publications were not

understood, being refused by my medical contemporaries who did not know the second principle.

The second principle is the most important and most illuminating of all Nature's laws so far as we know them. It is the law of probability in natural happenings at the same time as the law of direction. It postulates the pre-existence of a state of *order* or *organisation* of energy, which becomes disordered or disorganised through working. It postulates that working always is a transition from order to disorder, that the world we know is provided with a supply of order which constantly decreases exactly in proportion as disorganisation (entropy) increases. It postulates that a graded scale leads from the highest organisation of energy known to us, down to complete disorganisation. It postulates that grades of the same organisation are in a balanced relation with one another, and may remain or sink in the process of transformation of one kind of energy into another, but cannot rise. It postulates that the level or grade of organisation, e.g. the temperature, is the measure of its working capacity or the grade's potential; that differences of level between two grades of organisation give rise to a potential-altitude or the power resulting from the differences of intensity of the two grades. It postulates that nothing can happen without such a potential altitude, i.e. without differences of intensity or differences in energy, and that ultimately the process or vehemence of what happens depends upon the dimensions of the potential altitude.

There are two kinds of processes: (1) Those which occur of *themselves*, whereby the grade of organisation (the potential) of the system's beginning state sinks into a lower grade in the end-state and the altitude between

the beginning and end grade performs the work accomplished by the system. These are called natural or positive processes. (2) Those through which a system is *raised* to a higher grade of organisation. This can only happen through a second system compensating through at least adequate decline of potential for the raising of the first system. These processes are termed unnatural or negative processes. In these processes a *new* organisation in a system is created at the cost of a higher organisation already existing.

The transformation of the sun's energy into food energy is a negative process in which new organisation of energy is created through chemical synthesis. What is peculiar about this organisation is that it is constituted under intelligent and vitally effective guidance. Thus not only reduction systems with high redox potentials are formed arising from reduction, but also systems of intermediary effects " conceived and calculated " for the regulation of future effects of energy in the process of life. Moreover, this occurs in such wise that all kinds of newly organised systems are formed in a definite harmonious relation of balance with each other, i.e. in natural correlation. I term this the biological-correlative organisation of food energy.

From the work performed by the redox potentials of food in the vital process it may be known that their maximum strength is equivalent to the potential of sunlight.

The life-process of animal and human organism is in the main and taken as a whole a natural or positive process which is accomplished by the organisation of energy existing in plants. Plant foodstuffs in their natural fresh state naturally convey this organisation.

A diet rightly composed of them provides the best nutritional energy for frugivorous man.[1]

Every alteration in state which this natural food passes through until it takes its place as a dish on the table is a natural process with increasing disorganisation and decline of potential. Altered states which disturb correlative harmony also decrease and injure the biological effect of food energy. I call a naturally fresh plant-foodstuff an integral of food. Every alteration of its correlative organisation must be accounted as disintegration.

In the animal organism the original vegetable organisation is transformed in accordance with the structure and working of the respective organs and tissues. For instance the muscle naturally contains high redox potentials derived from plant synthesis, as well as a not inconsiderable amount of partially or wholly oxidised grades. The changed organisation renders the muscle inadequate as food for the human organism's correlative needs. Admixture with grades of oxidation lessens its value as organisation. Add to this alterations of state due to after-death processes and to heat. Permanent nutrition with meat leads to allergic diseases owing to the interference-effects of the correlations of meat and the correlative needs of the human organism. Other interference with correlation are alluded to in these pages.

The energy altitude arises between the energy state of the food introduced and the end-state in which energy leaves its stationary framework, man. The altitude of

[1] This theoretical deduction merely leads to the conclusion that a diet correctly composed of raw plants is the most efficacious health diet for sick men.

the energy furnishes the power with which the energy stream in the body works, that is by which processes of metabolism can happen. The altitude falls with the degree of disorganisation and disintegration of the food introduced through the altered states spoken of. The chemistry of metabolism is thereby altered, that is deteriorated. Kollath says: "A change in the redox potentials must be followed by a chemical change." If imperfect combustion results the heightened level of the end-state of the energy leaving the body reduces the total altitude. Ultimately this leads to reduction of the redox potentials of the body's tissues and organs and thereby to reduced effective capacity of the redox systems (vitamins), the latter likewise proved by Kollath.

Through this state of affairs the part played by food in *pathogenesis* becomes evident.

On the other hand, if a man suffering from nutritional disorders is treated by a biological-correlative diet with full organisation, i.e. exclusively vegetable raw diet or an adequately corrected health-diet, the components of which have grown on healthy soil and are unobjectionably cultivated—the healing processes in the sick body will so far as possible regulate metabolism and re-establish health, provided no other causes of disease are involved. This shows the part played by food in hygiogenesis.

The theories deduced from the consequences of the second principle with regard to nutritive values, constitution, composition, and preparation of health diet, indications for therapy and prophylaxis through nutrition, as well as practical results of these methods during forty years of medical experience—my own and my fellow-workers—all these have been dealt with in my books and other writings, to which I now refer to avoid

repetition. I have also not mentioned the manifold points in which my experience agrees with the results of recent research in nutrition.

May this theoretic work contribute to lead medicine to a logical application of the second principle to all processes of nutrition and disease, and may the theory of the nature and organisation of food energy undergo a thorough transformation.

I do not worry about the way in which the medical profession receives this book. I have forty years' experience of the therapeutic paths indicated, in the course of which various developments and enlightenment resulted. Hence I believe it is my duty to acquaint others with the ideas outlined here, although the book was by no means easy to write. No one can deny that my standpoint is the result of many hours of concentrated study, untiring reflection, and conscientious control, by what actually occurs in life.

I am only concerned with one thing: The realisation of this theory in life and in the region of disease, which is no easy matter. It all depends upon how it is done.

"Thou hast a way, but it is difficult to walk in
Those which are easy are not heaven sent"

says Tschuang-Tse.